THE ENGINEER

JUNE 18, 1954

Parsons Centenary Exhibition

AT the Stephenson Building, King's College, of the University of Durham, Newcastle upon Tyne, there has been arranged an exhibition of the work of Sir Charles Parsons, commemorating the centenary of his birth, June 13, 1854. It was officially opened this week by the Lord Mayor of Newcastle. Among the principal exhibits are working models of the earliest turbo-dynamos based on his two original patents No. 6734, describing his generator in detail, and No. 6735, the axial-flow steam turbine, by which it was driven. There is a ½kW model of his first set, which developed 7·5kW and consumed 150 lb of steam per kilowatt-hour. Some 360 sets of up to 75kW capacity were made to this design by 1888. In the following six years, when precluded from using his axial flow patent, he developed turbines on the radial flow principle. A model at the exhibition of one of these, built in 1891, is of particular interest, for it was also the first condensing turbine. It was a 100kW set and it achieved a steam consumption as low as 27 lb per kWh, which was comparable with the best reciprocating engines. Development of the radial flow turbine, however, was dropped after 1894, when Parsons had access once again to his original patents. Development of the axial-flow turbines was thereafter rapid, and representative units are exhibited. In 1900 he was making sets of 1250kW with steam consumptions of about 18 lb per kWh, and in 1912 came the first of the double-cylinder tandem sets with a double-ended low-pressure cylinder, the output of this set, which was installed in Chicago, being 25,000kW with a steam consumption of 10·42 lb per kWh. The importance of blade development in this evolution is shown in a special section. It is recalled that the first blading he used up to 1888 was formed by simply cutting parallel-sided radial slots at the periphery of cast brass discs. His first kind of curved blade was formed in the same way, but the trailing edge was bent subsequently by hand. This shaping improved the efficiency by 25 per cent. He also tried caulking separate blades in slots machined on the disc, and in 1895 he first tried stamping blades with their roots from brass blanks. Parsons's work in the marine field is also well illustrated, particularly that associated with the "Turbinia," in 1894, and which with axial-flow turbines three years later achieved a speed of 34½ knots. Apart from the many other fields into which his researches roved, there were many other urgent engineering problems whose solution was thrust upon him. His original torsion meter is exhibited, together with a vacuum tank with which Parsons first investigated, using stroboscopic light, propeller cavitation. Other items show his fundamental work in the design and manufacture of reduction gearing and bearings, and a host of other exhibits testify to his inventive genius in the air, on the land and at sea. Following the ceremony Professor Aubrey Burstall, president of the Stephenson Engineering Society, gave an address entitled "The Place of Sir Charles Parsons in the History of Mechanical Engineering."

Engineering Centre at Birmingham

THE new Engineering Centre established by the Birmingham Exchange has now been opened and its services are available to industry. This Centre is organised on a non-profit-distributing basis, and is designed to provide a permanent exhibition for the products of the engineering and allied industries. It will not only enable buyers and manufacturers from home and overseas to inspect a wide range of products, but with its central position in Stephenson Place, Birmingham, provide a convenient rendezvous for all interested in the manufacture, purchase and distribution of engineering plant and accessories. To handle inquiries relating to sources of supply, sub-contracting, local representation, &c., a comprehensive information department will maintain an up-to-date library of catalogues, trade directories, reference books and standard specifications. With the facilities at its disposal one of the objects of the Centre is to assist small firms with their problems in seeking and exporting to new markets abroad, and to introduce manufacturers to overseas buyers. A further aim is purely educational, and engineering students and apprentices will be encouraged to visit and use the facilities of the Centre in connection with their studies. The exhibits are particularly well arranged for easy inspection and at present the products of some 200 firms are displayed by means of actual equipment, models, panels and photographs. A smaller adjoining exhibition hall is available for private short-term exhibitions, and there are also lecture rooms with facilities for film projection.

Report on Derailment at Bethnal Green Station

ON Wednesday of this week the Ministry of Transport and Civil Aviation issued its report on the derailment which occurred on Friday, September 4, 1953, when the 2.21 p.m. express passenger train from Liverpool Street to Ipswich was derailed outside Bethnal Green Station. The accident, the report recalls, occurred at a crossover leading to the down suburban line, due to the irregular operation of the facing points, and the engine and tender remained on the main line while the remainder of the train was diverted, the first, second and third coaches being derailed, but without resulting in any serious injury to the passengers. The inquiry into the causes of the accident was carried out by Brigadier C. A. Langley, and his report concludes that irregular operation of the points machine caused the reversal of the points under the first coach of the train. The cause of this movement, it is stated, could only be by a false feed through a cross connection of the 110V d.c. circuits, a connection which was made inadvertently by a lineman working on the circuits. In his remarks Brigadier Langley states that although the accident was primarily due to a lineman's mistake, some of his equipment was not suitable. It is particularly emphasised that wander lamps with uninsulated wire guards should not be permitted in a relay room and that all such lamps had been replaced by others fitted with insulated guards. Another point made is that the slipping of a terminal link, which could easily occur if adequate care was not observed, was the possible cause of the accident. Furthermore, according to the report, the style of link in use at Bethnal Green is of obsolete pattern and is in course of being replaced by a modern link having a slotted fibre extension, which makes certain that the link cannot slip and make contact with other terminals when it is moved to break the circuit. Another item, to which attention is called, is that the insulation of certain pole changer coils was below standard and the serious nature of a breakdown of the insulation of point machines is mentioned, although this particular defect did not contribute to the causes of the accident investigated.

Institute of Materials Handling

MORE than 250 members and guests attended the annual dinner of the Institute of Materials Handling which was held in London on Friday last under the chairmanship of Mr. J. Bright. In a speech proposing the toast of the Institute, the Earl of Onslow said that industrial prosperity was dependent upon producing what was wanted to the required quality and, what was more difficult, at the lowest possible price. In connection with this last condition the manufacturers and designers of mechanical handling equipment in this country were doing their part in providing plant which assisted appreciably in speeding production and reducing costs. The Earl of Onslow went on to say that in his opinion the difficulties experienced in introducing mechanical handling equipment in certain industries could be overcome by closer relationships and better understanding between men and management. He asked the mechanical handling industry if it would not be possible to introduce a cheap and efficient range of equipment for use in the agricultural industry. In replying to this toast Mr. Bright pointed out the significant contribution the industry was making in the national cause, and spoke of its future plans to widen its field of service. The guests were toasted by Mr. H. P. Mott, and in his acknowledgment Mr. W. J. Brown pointed out that with mechanical handling, industry in this country was on the threshold of a great era of economies if the principles of mechanical handling were adopted to their fullest extent. It was estimated that by the fullest possible use of such equipment savings of up to £500 million a year could be made.

Association of Mining Electrical and Mechanical Engineers

THE forty-sixth annual convention of the Association of Mining Electrical and Mechanical Engineers has been taking place in Glasgow this week, during the course of which members have been able to visit a number of works. On Thursday a paper entitled "Maintenance of Mining Plant" was read by A. E. Crook, and to-day Sir Harold Roxbee Cox delivers the Thornton Lecture, and the meeting concludes with the annual banquet and ball. On Wednesday last the incoming president, Mr. B. L. Metcalf, gave his presidential address, which was entitled "The Competent Person." It was largely devoted to the subject of education and training. At the outset of his remarks the president said that to advance the status of the profession it was essential that the designation of engineer should be reserved for corporate members of senior institutions. The passing of examinations, he went on, did not make an engineer, but rather academic education plus years of practical training and considerable experience of responsibility. Great opportunities existed in the mining industry for the making of engineers, due to the wide variety of problems which had to be solved, and, he continued, the Coal Board had a three-year course of directed practical training, which afforded the trainee the opportunity of undertaking responsibility. Mr. Metcalf touched upon the need for helping graduates to acquire specialised techniques, and hoped that the new National Coal Board Central Engineering Establishment would find a place for those with a flair for design and invention. However, the basic need of the industry was for men with sound engineering training and the ability to apply it, and the president continued by suggesting that more use would be made of works based sandwich courses to qualify men for a Diploma in Engineering and so provide good material for the industry. The president condemned the idea of a single training course for all entrants as being against the interests of the industry, which would benefit from a greater infiltration of new blood from other industries. Education and training for technicians was also dealt with, and Mr. Metcalf felt that what was required was a course which helped the student to understand how apparatus operated and why it failed.

Some Recent Swiss Hydro-Electric Schemes

No. IX—(*Continued from page 844, June 11th*)

The series of works built by the Oberhasli Company in the upper catchment of the Aare are amongst the best known of Alpine hydro-electric schemes ; several of the more recent additions to this system are described here. The article includes notes on the Oberhasli Company's methods of organising work in mountainous country, and on Swiss practice generally in the design and protection from corrosion of pressure shafts.

THE Oberhasli Company's hydro-electric works, which extends along the upper part of the Aare valley from the Grimsel pass to Innertkirchen, form one of the most important systems of hydro-electric power stations in Switzerland. The older works are well known, and have been described in this journal ; at the time of the construction of the Spitallamm and Seeuferegg dams, which form the Grimsel reservoir, we printed a short description of these works (THE ENGINEER, November 22, 1929), and when Innertkirchen power station had recently been completed we published a series of articles describing the scheme as it then was (THE ENGINEER, March 5 to April 16, 1943). Since that date further important extensions have been under construction. The entire system is shown in the map Fig. 40. It is

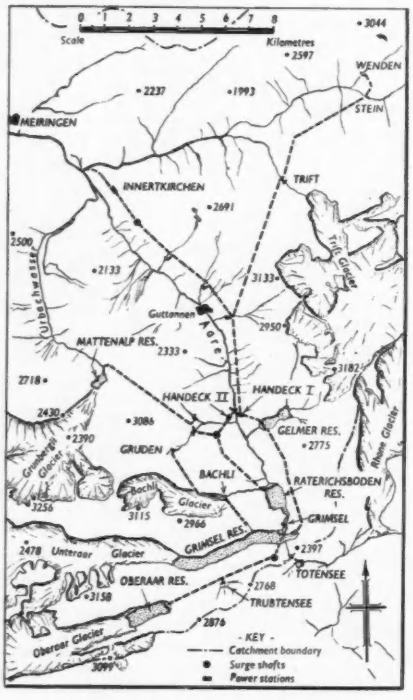


Fig. 40—The Oberhasli development

convenient for explanation, to consider the right and left bank works separately. The right bank system consists of the Grimsel reservoir, with a diversion tunnel leading from it to the Gelmer reservoir ; a pressure shaft descends from the Gelmer reservoir to Handeck I power station. These two reservoirs and Handeck I power station formed the first stage of the scheme. The second stage comprised the diversion works and the power station of Innertkirchen—an underground power station—and was completed in 1943, as described in our earlier series of articles.

The other works shown in Fig. 40, principally the left bank system, have been under construction since 1947. The first of them to be completed was the Handeck II power station, the principal data for which are given in Table VIII. This power station is built underground and is generally similar in design to the earlier one at Innertkirchen. There is a small reservoir at Mattenalp, on the Urbachwasser, as Fig. 40 shows, with diversion works to the power station incorporating subsidiary intakes from two other streams. The principal reservoir of this part of the scheme is, however, the Räterichsboden reservoir. Sufficient storage could not be provided economically at Mattenalp, but the flow from there may be stored in the Räterichsboden reservoir. The catchment supplying Mattenalp reservoir is 36·2 square kilometres in extent, whilst that supplying Räterichsboden (excluding, of course, the catchment controlled by Grimsel reservoir) is only 14·5 square kilometres. Further figures for these two reservoirs and the other reservoirs of the scheme are given in Table IX. Räterichsboden dam was completed in 1950.

TABLE VIII—*Power Stations of the Oberhasli Scheme*

	Generating sets	Installed capacity,	Gross head, metres	Power production		
				Summer, kWh × 10^6	Winter, kWh × 10^6	Total, kWh × 10^6
Handeck I	Four vertical Pelton	4×28MVA	545·5	140	160	300
Innertkirchen	Five vertical Pelton	5×52·25MVA	672	380	240	620
Handeck II	Two Vertical Pelton (initial installation)	2×40MW	463	140	30	170
	Ultimate installation, four sets	4×40MW				
Grimsel (Oberaar)	One horizontal set, driven by two overhung Pelton wheels	45MVA	536	−190	220	30
	One pump, 29,000 h.p., 4m³/sec		400	—	—	—
	Power production of entire scheme :					
	(*a*) Before completion of Grimsel power station			660	430	1090
	(*b*) After completion of Grimsel power station			470	650	1120
	(*c*) Additional energy from right bank diversion (Trift, &c.)			200	10	210
	Total			670	660	1330

TABLE IX—*Reservoirs of the Oberhasli Scheme*

Reservoir	Top water level, metres above sea level	Storage capacity, cubic metres × 10^6	Catchment, square kilometres	Annual run-off, cubic metres × 10^6
Grimsel	1909	100	95·5	200
Gelmer	1849	13	16	30
Mattenalp	1875	2	36·2	70
Räterichsboden	1767	27	28 (14·5 additional catchment)	46
Oberaar	2303	58	(21) (included in Grimsel catchment)	(38)
Trubtensee	2365	1		
Totensee	2160	2·5	2·0	4
	Totals	203·5	164·2	350
Additional catchment areas :				
Left bank :				
Gruben			5·5	10
Bächli			8·1	15
Right bank :				
Sidestream intakes to Innertkirchen tunnel			10·3	15
Wenden			12	24
Stein			30	60
Trift			39	80
Total catchment area and run-off of entire scheme			269	554

It is similar in general conception to the Oberaar dam, as described further on. The flow from the tail-race of Handeck II power station is diverted through a small compensating reservoir, into the intake tunnel of Innertkirchen power station. Such an increase in flow was envisaged when the latter power station was designed, and on completion of the left-bank works described above additional generating sets were installed at Innertkirchen to bring it to its ultimate installed capacity. A small additional reservoir—Totensee reservoir—was also built whilst these works were in progress. It adds a small catchment area (previously draining into the Rhone) to the scheme, and is connected directly with the Grimsel reservoir.

The next stage of development, which has at the present time reached an advanced stage of construction, does not add to the total catchment area, but utilises an additional head, and makes possible the generation of a greater amount of winter power. It involves the construction of a major storage reservoir at the foot of the Oberaar glacier—the highest storage reservoir of the scheme—and a new power station at Grimsel. The diversion tunnel from the Oberaar reservoir passes under the Grimsel reservoir to the new power station, whose tail-race discharges into Räterichsboden reservoir. There is a pump in the power station, so that when surplus power is available in the summer water may be pumped from the Grimsel reservoir up to Oberaar reservoir. Thus, to increase the yield of winter power and to utilise the head from Oberaar, the old right bank system will be robbed of some of its water, which will now pass through Handeck II instead of Handeck I power station. There is also a small subsidiary reservoir—Trübtensee—forming part of the Oberaar works.

There is also one other work under construction in the left bank system. It consists of two unlined tunnels, one from the foot of the Gruben glacier to the Bächli glacier, and a second from a small weir at the foot of the latter glacier to the Grimsel reservoir. Thus the flow from these two glaciers will be stored at Grimsel. On the right bank a major collecting aqueduct is under construction to bring the waters of the Wenden, Stein and Trift, three glacial streams, into one of the side stream intakes leading to Innertkirchen power station. There is no suitable site for a storage reservoir in the catchment of these three streams, which will therefore give some 200kWh to 300kWh of additional summer energy. A final work which may possibly be undertaken to increase the winter power output of the completed scheme involves the raising of the two dams of the Grimsel reservoir by 14m, thus increasing its storage capacity by 50 million cubic metres. It would then be necessary to install additional pumping plant to pump water from Räterichsboden to Grimsel reservoir, but this project is not yet being investigated in detail.

CONSTRUCTIONAL WORKS

The highest works of the Oberhasli scheme are not at higher elevations than corresponding works of other Alpine hydro-electric projects, but are situated in an area, close to one of the largest blocks of glaciers to be found in the Alps, where the natural conditions of climate and terrain are particularly

severe, and the inclemency of the mountain climate is in many cases the greatest difficulty to be overcome. The Oberhasli Company has gained considerable experience over the many years during which it has had projects in progress in this area, in the best method of organising its works so that these difficulties may be minimised, and constructional works may be started early each spring, and kept in progress late into the autumn.

Guttanen is the highest village in the valley which can be reached all the year round. When the first power station of the scheme, Handeck I, was built, an access tunnel was driven from Guttanen to Handeck, for winter access and to take the high tension transmission cables. From Handeck, a ropeway has been built to give winter access to Räterichsboden dam, and from there a tunnel has been driven to Grimsel power station. There is a ropeway from Räterichsboden dam, leading (in this case it is the only means of access) to a constructional camp at the foot of Bächli glacier. At Grimsel, the power station and all its auxiliary facilities are underground. There is then another ropeway up to the high ground between the two dams close to the Grimsel Hospiz, and from there a ropeway across the reservoir and along the mountainside to Oberaar dam. Power from Grimsel power station is to be transmitted to Räterichsboden dam with underground high tension cables, and from Räterichsboden dam to Handeck along a conventional overhead line. From Handeck to Guttanen, a proportion of this power will be transmitted by high tension cables passing through the tunnel built for the earlier part of the scheme, and the remainder by an overhead line built in 1950.

The Oberhasli Company arranges its projects as far as possible so that an even flow of work is maintained over the years. The company itself employs only a few specialist workers—for instance, for grouting work, for construction and operation of the ropeways and for control and maintenance of plant—but it tries to encourage the key workers to remain on its scheme for long periods. Many of the workers on Swiss hydro-electric schemes immigrate, principally from Italy, but also from Austria and Germany. The company arranges the immigration formalities, &c., for many skilled workers who are then employed by the successful contractor.

Contracts for the main works of the various projects do not include such subsidiary items as constructional camps and access facilities. The company finds that, with its long experience of local conditions, it is better to carry out these works to its own requirements by separate contract, and several local small firms of contractors are kept occupied in this way. Thus, the risk to a contractor of undertaking a major work in some exposed area of the mountains is limited to the main work itself. The power company takes all the responsibility for workers' camps and access roads, tunnels or ropeways, as the situation may require. It obtains more favourable tenders with this policy than would otherwise be possible, together with several other advantages, such as the maintenance of a given standard of accommodation in constructional camps.

This policy has given good results with some of the more remote works. For instance, the camp at the foot of the Bächli glacier, at about 2200m above sea level, is in a particularly exposed valley and access is by ropeway only. The company's fund of experience of local conditions was used to good account here, in the establishment of the necessary preliminary works. Another example is given by the tunnelling works beyond the right bank of the Aare ; a large building, constructed of local stone, has been built in the Trift valley to facilitate the tunnel construction in progress there. Before these works were started, the Trift valley had never been accessible in the winter months, due to the frequency of avalanches.

Life on the more remote sites is likely to be monotonous and so as to encourage long service, the company organises facilities such as cinema or variety shows which visit the various sites at intervals. At Innertkirchen there are permanent buildings for the staff there, and the company has set a high standard with a number of elegant houses of modern design which it has built for the accommodation of engineering staff. It also encourages the communes to make constructive use of the payments they receive for hydro-electric concessions, and has organised, for instance, the building of local schools. By arranging an even flow of works over a long period, in the manner described above, the company thus considers that it achieves no small measure of economy, whilst at the same time promoting local interests and amenities.

Pressure Shaft Design

The more recent elements of the Oberhasli scheme, namely, Grimsel power station and Oberaar and Räterichsboden dams, will now be described in more detail. There is much evidence of continuity in the design trends of the various elements of the complete scheme. Thus, Handeck II power station is very similar to Innertkirchen power station, described in our earlier article, and the general conception of the Oberaar and Räterichsboden dams is very similar. Also, all the diversion works end in rather similar surge shaft arrangements, and in an inclined pressure shaft. Some troubles have been experienced in the older pressure shafts due to corrosion, and as this aspect of Swiss hydro-electric design is not without topical interest a few words on the Oberhasli Company's latest ideas, and those of some other Swiss concerns, about these shafts may not be out of place.

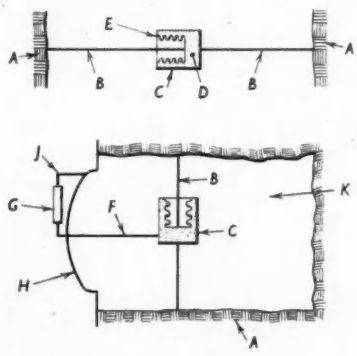


Fig. 41—Pressure test apparatus

Several years ago, a method of measuring the deformation of the lining of such a shaft or of the rock surrounding it, was devised by Sulzer Brothers, Ltd. The apparatus used consists of a number of steel rods which are fastened across the diameter of the section to be tested. When the section is put under pressure deformations are transmitted to the rods, where they are taken up by spring bellows fitted at the centre of each rod, as shown diagrammatically in Fig. 41. The bellows is placed in a sealed cup filled with liquid ; any alteration in length of the rod causes a corresponding change in the volume of the bellows, and hence a displacement of the sealing liquid, which is measured through a connecting pipe, on a gauge outside the test section. The increase of pressure in the test chamber itself is compensated on the gauge by the arrangement shown in the second diagram of Fig. 41, where a pipe connecting the top of the gauge with the test chamber may be noted. The sealing liquid is coloured and has a high density ; it will not mix with water and is thus not affected by the compensating connection. In the first instance the gauge had to be calibrated.

In practice, as large a test chamber as possible is selected for test with this equipment and subjected to tests (*a*) with the untreated rock surface, (*b*) after placing the steel lining ring in position and backing it with concrete, and (*c*) after the completion of grouting with cement grout up to a specified pressure. The apparatus has been used on a number of hydro-electric schemes, including the Grande Dixence scheme, described earlier in this series. With its use, it is possible to get a good idea of the proportion of the pressure in a shaft which is taken by the steel lining, and the behaviour of the rock behind it. The information thus acquired has indicated that in most cases a comparatively thin steel liner is sufficiently strong, even in bad rock, to take the water pressure inside the shaft. Thus it has led to the belief that the stability of the shaft, when empty, to withstand external pressure is an important design criterion.

The design of the Oberhasli Company's pressure shaft leading to Grimsel power station is based upon ideas similar to those outlined above. Thus the resistance to bursting of the combined steel liner and rock backing, with the full hydrostatic head in the shaft, is not considered to be critical. The thickness of the steel liner is determined from the following criterion. With the shaft empty a hydrostatic head equal to the vertical distance from the shaft to the ground surface above it is considered to act from the outside on a quarter of the circumference of the steel liner. The liner is then proportioned to withstand, within appropriate limits of stress, the load so imposed. That criterion is, we understand, fairly generally applied in Switzerland to determine the thickness of steel liners.

Whether or not the pressure of the water in the surrounding rock can be kept away from the outer side of the steel liner depends on the construction generally and on any drainage arrangements which can be made. In the experience of the Oberhasli Company, it has been found that the concrete backing is always porous ; temperature changes cause relative movements, or the concrete may deteriorate, perhaps due to percolation. Also, even after repeated grouting, it has been found impossible to eliminate small hollow spaces behind the liner (discovered by tapping the pipe) which appear haphazardly. All this information supports the external pressure method of design, the application of which to the Handeck II pressure shaft was noted in an article* by Dipl.-Ing. J. Bächtold, chief engineer of the Oberhasli Company, in which the design analysis was given and from which some of the accompanying information was taken. The stability of the liner, it was concluded, is proportional to

$$\left(\frac{\text{thickness of metal}}{\text{radius}}\right)^4$$

which favours a generous thickness for a given pipe diameter. For instance, an

* Schweizerische Bauzeitung, 1952, Nos. 41 and 43. See also No. 19, 1953.

increase from 12mm to 14mm in the thickness of the liner of a 2·25m diameter shaft gives double the security against internal deformation.

In the case of the shaft leading to Grimsel power station there was, however, an added complication. The shaft passes down in the rock beside the Grimsel reservoir, and then under the reservoir to the power station. It passes underneath the base of the Spitallamm dam, and so as to avoid any possibility of altering the rock stresses underneath the dam, a steel pipeline is carried, freely supported, in a tunnel under the critical zone. The pressure shaft itself descends at a slope of 64 per cent for about 800m and then passes, level, to a diaphragm, well under the Grimsel reservoir, where the freely supported penstock starts. The shaft is 1·65m in diameter and has a steel liner varying from 10mm to 13mm in thickness, backed with a minimum thickness of 8cm of concrete. The shaft is 1600m in length altogether, but the steel-lined section is 1440m in length. The maximum head acting on the shaft is 536m. The minimum rock cover over the pressure shaft section is about 63m (at the point where the construction changes) and there is a minimum of about 90m of rock cover over the horizontal part of the shaft where it passes under the reservoir; where the alternative construction is employed under the base of the dam, the rock cover reduces to a minimum of about 6m.

In practice the steel liner was placed, from the bottom of the shaft, in lengths of 10m. The joints were butt welded with outside cover straps, and the welded joints were all radiographically tested. After the backing concrete had been placed grouting was carried out in stages up to a maximum pressure of 40 atmospheres, this final stage of grouting not being carried out until some weeks after the earlier stages.

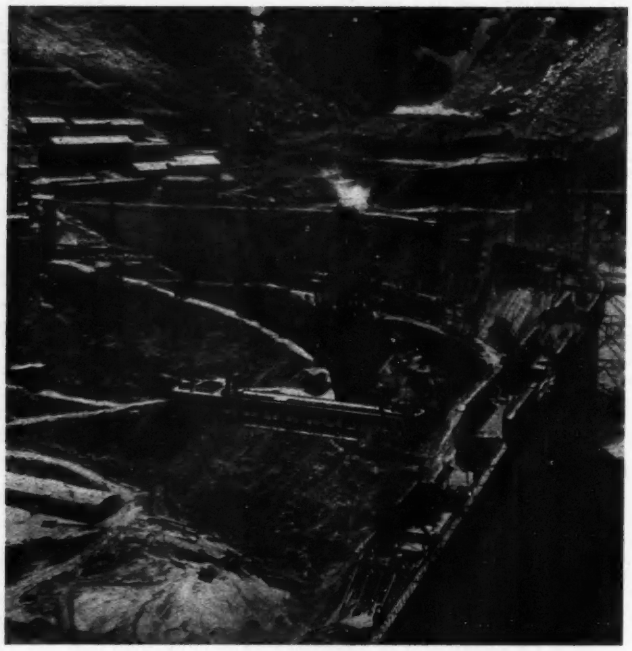


Fig. 42—Oberaar dam shortly before completion

For the concreting work it was found from tests on the Handeck II shaft that concrete could be pumped for distances up to 220m and height up to 35m without difficulty. Radiographic testing of the welds is thought to have been an innovation for this class of work, and is considered by the company to be more advantageous than X-ray testing for the particular conditions of the pressure shaft. Although less sensitive than the latter method, it gave sufficiently sharp photographs to demonstrate clearly any weld defects. Isotopes of iridium (192) and cobalt (60) were obtained from this country, and sent back for reactivation from time to time. A capsule of the isotope was inserted between the liner pipe and the rock, in a long rod, and a strip of film was fastened on the inside of the weld to be tested. Some bad faults were found in the first welds tested in this manner, although the work was carried out by firms of repute, but later the standard improved, and apparently one of the main advantages of the testing was its psychological effect, for consistently good welding was found as the work got under way.

When construction of the Grimsel pressure shaft was complete, it was filled with water and subjected to a pressure test, with a maximum pressure of 40 atmospheres in the centre of the shaft. The volume of water introduced for a given rise in pressure was measured, and, hence, the stress in the steel liner deduced. This was found to be 483kg per square centimetre corresponding to a pressure of 40 atmospheres, or about 800kg per square centimetre for 65 atmospheres (equivalent to working pressure plus allowance for water hammer at the base of the shaft). It was also computed that the steel liner was carrying a quarter of the total load, and the surrounding rock three-quarters.

Corrosion Protection

The precautions taken to protect the steel liner from corrosion are not without interest; they are based on researches carried out for a German hydro-electric scheme—the Schluchseewerke project in the Black Forest—and verified by the Oberhasli Company. It was established in these investigations, which were based on microscopic examination of cross sections of a steel liner, that the bond of any protective coating to the steel, whether it was paint or a metal spray, depended on the elimination of very small bubbles between the coating and the steel. Furthermore, it was established that these small bubbles consisted of water vapour, and for the successful bonding of a protective coating it was therefore necessary to apply it in the absence of water, in a dry atmosphere.

Considerable trouble was therefore taken to dry out the pressure shaft. A heating plant of 180kW capacity was installed at the foot of the shaft, giving an air temperature of some 16 deg. Cent. (the work was carried out during the winter), which was maintained for several weeks until the work was finished. So as to keep the relative humidity low, air was blown through the shaft at a velocity of 1·5m per second. Compressed air for operating the metal-spraying and painting plant was passed through cooling tubes, around which glacial water flowed, and condensation was drained away. Finally, it was passed through a silica gel dryer, thus giving it a relative humidity of about 5 per cent. The protective coating was then spread on by the use of this compressed air. The spraying tool included an air jet on each side of the spray, so that a jet of air played on each side of the actual part being coated, to ensure complete dryness.

The various treatments given to the steel liner of the pressure shaft were as follows:—(*a*) sand blasting; (*b*) zinc spraying; (*c*) two coats of rapid-drying bituminous paint; (*d*) a thick coat of bitumen placed hot (the drying precautions were not necessary for this coat); (*e*) two coats of bituminous paint, containing respectively 20 and 60 per cent of aluminium powder. The contractor who carried out this work has, we understand, given a ten-year guarantee against corrosion of the steel liner.

As part of these developments a machine has been developed for the cleaning of the steel pipes forming these pressure shafts. It was used, instead of sand blasting, for preparatory cleaning in the Grimsel pressure shaft, and will be employed for cleaning the Handeck I and Innertkirchen shafts.

A very similar approach to the various problems of the pressure shaft for the Verbano power station has been adopted by the Maggia Kraftwerke, a company which is constructing a hydro-electric project near Locarno, which is described in Part X of this series. But with these works the 10m lengths of the steel liner were given their various protective coatings in the factory, where control of moisture content was a simpler matter. The hot bitumen coat, which is something of a novelty, was not used in this case. A width of 10cm at each end of each pipe was left free of protective coating so that the joints could be welded on the site. The 20cm strips thus left unprotected were later zinc-sprayed and painted without any special precautions being taken to remove moisture, but the work was carried out during the winter, when the relative humidity is often lower than at other times. In this case the shaft is subjected to a head of 297m and a rated flow of 44 cumecs; its diameter varies between 3·0m and 2·8m and it is 547m long. The maximum thickness of the steel liner is 26mm and the nominal thickness of the concrete packing is 15cm. The shaft has been excavated in gneiss of good quality. Tests carried out with strain gauges indicated that 50 to 60 per cent of the hydrostatic pressure was taken by the rock.

Oberaar and Räterichsboden Dams

The principal dimensions of the two most recent dams built by the Oberhasli Company are given in Table X. As we have already mentioned, there is much similarity in the general conception of the two dams, which are both gravity structures. A point of particular interest in their design is that they each have open joints in the form of hollow chambers. Both dams were constructed in blocks, 18m long, and extending across the full width of the dam. A chamber 3m wide was built between each pair of blocks, extending to almost the full height of the dam, and to within a few metres of each face. A steel sealing strip enclosing a core of bitumen was built in between each pair of blocks near the upstream face. The chambers allow a small economy in concrete, but

Table X

	Oberaar	Räterichsboden
Height, metres	105 ...	89
Length, metres	526 ...	456
Concrete volume, cubic metres	450,000 ...	276,000

Fig. 43—Construction of Oberaar dam

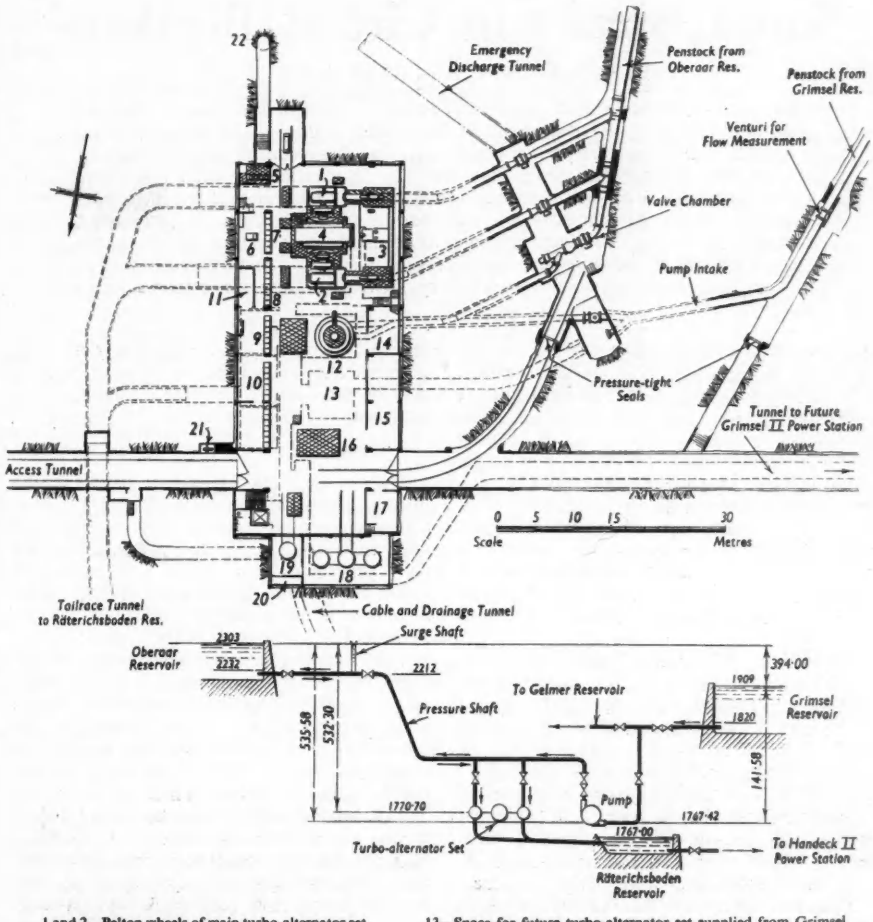
their principal purpose is to relieve uplift pressure; they are also of value, however, in providing an extra cooling surface for the newly placed concrete. On the downstream side of the chambers no attempt has been made to key together the joints between adjacent blocks. Thus, at Räterichsboden, these joints have allowed rainwater to penetrate to the chambers; a bitumen seal has, therefore, been incorporated between each pair of blocks on the downstream face at Oberaar dam, to keep the chambers dry, as they are used for inspection and for access to the valves of the scour pipe.

The Oberaar dam is founded on gneiss and is curved in plan, consisting of the principal, highest, length facing the Oberaar glacier, and a "wing wall" of smaller height almost at right angles to it, connecting it with the higher rock downstream. It is shown under construction in Figs. 42 and 43. It will be observed that concrete for the main section is placed from a concrete distributor suspended above the dam, and the "wing wall" is being built with tower cranes. The concrete batching and mixing station is conveniently situated in the angle between the two parts of the dam, with a long conveyor belt from the aggregate silos and preparation plant. This plant and the cement silos are situated on higher ground behind the dam, close to the constructional camp and the ropeway terminal. Fig. 42 shows construction at Oberaar dam in July, 1953, shortly before the dam was finished. The concrete distributor may be observed placing concrete in the crest of the main portion of the dam. The "wing wall" section of the dam is behind the concrete plant, where a tower crane may be observed. The rail track for the concrete skips may also be seen extending from the concrete plant to a position underneath the cableways which carry the skips to the distributor. The aggregate storage area is in the background, with the constructional camp partly shown on the left, with stockades for avalanche protection behind it. Fig. 43 shows an earlier stage of construction in 1952, with the main part of the dam in the centre, the future reservoir behind it, and the Oberaar glacier in the background.

Apart from the ropeway from the Grimsel Hospiz, there is also access to the site during the summer by a road, which is wide enough for only one line of vehicles, and is thus kept open in each direction for an hour at a time. There is also a cement ropeway which comes from Oberwald in the Rhone Valley. Oberwald is the highest railway station in the Rhone Valley which is accessible all the year round, and was chosen for that reason.

Aggregate for the dam is quarried in the moraine, of which there are extensive deposits in the bottom of the future reservoir, which will extend right up to the foot of the Oberaar glacier. A large stockyard of aggregate has been accumulated on the right bank, so that it was possible to start the storage of water in 1953, before the dam was finished. The concrete batching and mixing station contains three 3-cubic-yard mixers and like most of the plant, was used both at Oberaar and Räterichsboden. Two ten-hour shifts are worked and concrete is placed at an average rate of about 2000 cubic metres per day. With the care taken in organising the works, it is possible to concrete from May to November.

The concrete is made in two grades, for facing and hearting, with 280 kg and 160 kg of cement per cubic metre respectively, and water/cement ratios of 0·52 and 0·84 in the two cases. An air entraining agent—"Darex"—is added to the extent of 0·6 cubic centimetre per kilogramme of cement. The grades of aggregate are, in millimetres, 0–3, 3–8, 8–25, 25–60 and 60–180. The largest size is not used for the facing concrete. The concrete strengths obtained average about 350 kg per square centimetre for the facing concrete, and about 20 per cent less for hearting. By way of comparison, the maximum calculated stresses at Räterichs-



1 and 2—Pelton wheels of main turbo-alternator set.
3—Turbine governor.
4—Alternator.
5—Cooling water pumps.
6—Voltage regulator.
7—Alternator switchboard.
8—General switchboard.
9—Pump motor switchboard.
10—Switchboard for future alternator (Grimsel).
11—Light current apparatus.
12—Pump motor.
13—Space for future turbo-alternator set supplied from Grimsel reservoir.
14—Store.
15—Workshop.
16—Transformer servicing bay.
17—Fire-fighting equipment.
18—Three single-phase transformers.
19—Stand-by transformer.
20—Ventilation shaft for Grimsel II.
21—Ventilator.
22—Ventilation shaft.

Fig. 44—Grimsel power station

boden dam are, with the reservoir full, 6·6 kg per square centimetre at the heel, and 13·4 kg per square centimetre at the toe ; with the reservoir empty, these figures become respectively 19·4 kg per square centimetre and 0·4 kg per square centimetre. The downstream face of Räterichsboden dam is in three slopes, with a horizontal walkway constructed between each pair of them ; from top to bottom the slopes are 1 : 0·62, 1 : 0·69 and 1 : 0·78.

With the extra cooling surface given by the interior spaces, the maximum concrete temperature, measured by electrical resistance thermometers embedded in the dams, was kept down to 37 deg. Cent. Grouting was carried out on the upstream side and in the hollow spaces up to a maximum pressure of 40 atmospheres, with holes 45m long.

Both dams have a syphon spillway with a discharge capacity of 105 cubic metres per second, and a scour pipe ; there is then the principal intake to the power station.

Grimsel power station, which is at present under construction, is shown in plan in Fig. 44. It contains one horizontal-shaft Pelton-wheel-driven turbo-alternator set with two turbines and an installed capacity of 45MVA, and a pumping set. The capacity of the pump is 4 cumecs against a head of 400m, and its intake consists of a branch from the intake to Handeck I power station at Grimsel reservoir. The layout of the power station may be observed in the illustration, from which the access tunnel to a future Grimsel II power station may be noted ; this power station may be built, at the conclusion of the present works, if it is decided to increase the proportion of winter power generated by the scheme and, hence, the installation of pumping plant.

With the present installation it is intended to operate the pump at Grimsel power station during the summer to lift some 16,000,000 or 17,000,000 cubic metres of water to Oberaar reservoir between May and September ; with the natural flow thus supplemented, the reservoir will be full in the autumn. Then it is intended to operate the turbo-alternator set from the beginning of October for about 3100 hours ; rapid emptying of the reservoir is desirable at this stage so that losses due to the formation of ice are minimised. Storage will be maintained in Räterichsboden reservoir during this period, and the turbines in Handeck II power station will thus operate under their maximum head as long as possible. Fig. 44 also shows the provision made for the future installation of a second turbo-alternator set at Grimsel power station, to utilise the head between Grimsel and Räterichsboden reservoirs.

(*To be continued*)

Series Breaks in Circuit Breakers*

By F. O. MASON, B.Sc. (Eng.), A.M.I.E.E.

This article is concerned with a method of measuring voltage distribution. It shows how, in investigating the manner in which restriking voltage divides between series breaks in a circuit breaker, errors can be introduced in recording and in setting up the measuring apparatus, which may give rise to unreliable results. A simple comparison method is then described which not only ensures that the measuring apparatus has a minimum influence on the normal operation of the circuit breaker, but also enables the recording equipment to be checked for accuracy in situ in the test circuit and at test voltage. A section is included which shows how the method can be extended to determine the natural open-circuit voltage distribution between the breaks.

IN an investigation being carried out by the E.R.A. at Perivale on the voltage distribution between series breaks in circuit breakers, it soon became apparent that, unless great care was exercised in making the required measurements, significant errors could easily be introduced. Whilst the difficulties of measurement associated with this particular problem are generally appreciated, the required accuracy may be difficult to meet, and it was therefore considered desirable to find some method which would be relatively simple, and yet avoid serious errors.

The present article deals mainly with such a method, and shows a way in which the necessary recording apparatus may be set up to ensure a reliable assessment of voltage division under actual test conditions. For completeness and because it is not always realised to what extent errors in recording may affect results, a section is included which outlines the possible forms of error which can be introduced into the type of investigations under consideration.

It is perhaps advisable to point out here that corona currents may influence the voltage distribution across the breaks, although their effects are only likely to be of importance at the higher voltages. This particular problem is more a question of design, and is not dealt with in the present article. However, the possibility of such currents should not be overlooked, and it may be possible, by suitable design in stress distribution,[1] to mitigate their effects.

* Based on Report Ref. G/T281 of the British Electrical and Allied Industries Research Association.

Sources of Error in Recording

Errors Due to Measurement.—In the normal course of measurement of high-power transient currents and voltages, instruments and measuring apparatus are used which will generally give values of measured quantities having accuracies of the order of plus or minus a few per cent.

Generally, of course, in the type of power circuit such as is associated with circuit-breaking research, an accuracy of the order of ±5 per cent is tolerable. However, where a comparison of two or more values is concerned, as is the case where the division of voltage across series breaks is being investigated, errors in measurement of individual values take on greater significance, e.g. a direct comparison between two voltages, each having an accuracy of ±5 per cent, may give the ratio with an accuracy of only approximately ±10 per cent. This accuracy may be further reduced when any voltage value is obtained indirectly. For instance, it is not always practicable to measure the voltage across each break directly, and in a circuit with one side earthed it is common practice for voltage measurements, in the case of two breaks in series, to be made as indicated in Fig. 1, where the voltage across the top break A is obtained by subtracting the two voltages V_0 and V_1. Under these circumstances, with the measured voltages V_0 and V_1 having accuracies each of ±5 per cent, the ratio between the voltages across the two breaks, i.e. $V_1/(V_0-V_1)$, may be liable to an error of the order of ±20 per cent.

One possible source of error will be in the potential dividers used for recording the voltages V_0 and V_1. If they are resistance-capacitance dividers as indicated in Fig. 1, they must each be balanced, and if this is done by individual measurement of the parameters, eight of them are involved, and great care will have to be exercised if measurements are to be relied on to have as small an error as ±5 per cent at all frequencies.

It is, of course, possible to use potential dividers using capacitance alone. However, with such an arrangement, to avoid error, it is necessary to be certain, in the present investigation, that the time constant of the divider formed by the capacitance and inherent leakage resistances is large compared with one-hundredth of a second. If this is not the case, recorded voltage will be modified in accordance with the manner in which resistance is distributed across the divider arms, and these are unlikely to have the appropriate ratio, particularly as it is usually

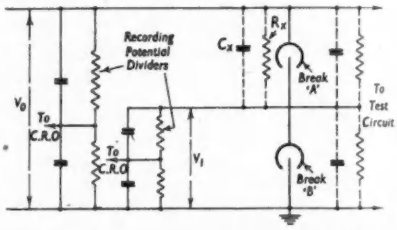


Fig. 1—Usual Arrangement of Potential Dividers for Recording Voltages Across Series Breaks

necessary to connect some resistance across the lower arm to prevent spot drift of the C.R. tube.

The kind of error that may be introduced under such circumstances is given in Fig. 2, which shows diagrammatically—Fig. 2 (*a*) (i) —arc voltage, followed by the restriking voltage. Fig. 2 (*a*) (ii) shows the recorded voltage where the leakage resistance across the bottom arm of the divider is lower than that needed for balance, whilst Fig. 2 (*a*) (iii) shows the result when the resistance is higher than that required. It will be seen that in Fig. 2 (*a*) (ii) the measured restriking voltage $V_{(ii)}$ will be greater than $V_{(i)}$, the true value, and in Fig. 2 (*a*) (iii), $V_{(iii)}$ will be less. The magnitude of this error will, of course, only become of material consequence in cases where the arc voltage is a few per cent or more of the restriking voltage, but in the opinion of the author, unless leakage resistances are known to be consistently in the order of several hundred megohms, the use of a resistance-capacitance divider, where the value of the resistance parameter is under control, is to be preferred.

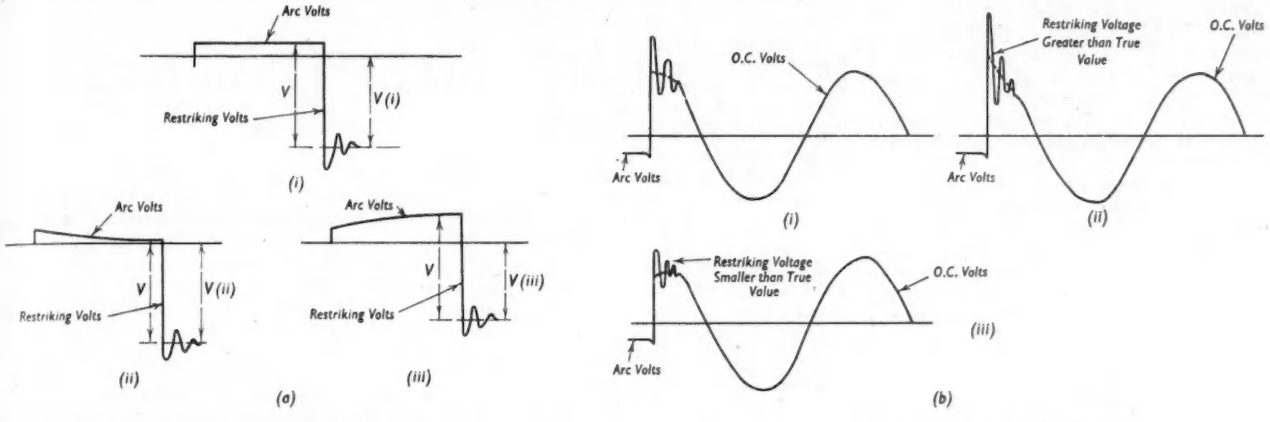
A further error which may be introduced by capacitance division alone, or by unbalanced resistance-capacitance division, is illustrated in Fig. 2 (*b*), which indicates diagrammatically restriking voltage followed by recovery volts.

Errors Due to Recording Arrangement.—Assuming the use of resistance-capacitance dividers, the general recording arrangement for two breaks in series, in a circuit with one side earthed, will then be as in Fig. 1.

As the arrangement stands, there has been added across the lower break B a shunt impedance, due to the divider, which does

not exist across the top break *A*. In order, therefore, that the recording apparatus may not modify the natural† voltage distribution across the two breaks, it is necessary to include across the top break a similar impedance, indicated here as C_x, R_x. Moreover, to be certain that the action of the circuit breaker is not appreciably modified, the added impedances across each break should be large compared with the natural impedance across each break during the current zero period.

It may be found, however, that practical considerations limit the capacitive impedance



(*a*) Effect of using capacitance division alone when time constant of divider is of the order of 10 millisec or less.

(i) True voltage.
(ii) Effect on recording where leakage resistance associated with lower arm is smaller than that required for balance.
(iii) Effect on recording where leakage resistance associated with lower arm is greater than that required for balance.

(*b*) Effects of using unbalanced dividers.

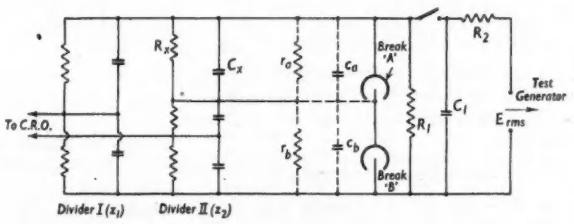
(i) True voltage record.
(ii) Capacitance in lower arm smaller than that required for balance.
(iii) Capacitance in lower arm greater than that required for balance.

Fig. 2—Diagrams showing possible errors in recording using unbalanced potential dividers

to something of the order of the circuit breaker itself, or even smaller, and this must be accepted, although its possible influence should not be overlooked.

The order of the inherent capacity of each break can usually be reasonably estimated from the physical dimensions, or measured, as indicated later, but the measurement of the arc's resistance during the current zero period is a separate and more difficult problem which has been dealt with elsewhere.[2]

Apart from the influence on actual voltage division, the capacitance and resistances added across the breaks must also be considered with respect to the possible modifying influence on the restriking volts, and thus the effective magnitude of the impedance of these parameters presented across the test circuit should be large compared with that obtaining in the absence of any recording equipment. Generally speaking, this requirement will be met if the requirement concerning the individual breaks is satisfied.



C_a and r_a—Effective capacitance and leakage resistance respectively for break $A = Z_a$.
C_b and r_b—Effective capacitance and leakage resistance respectively for break $B = Z_b$.
Z_1 and Z_2—Effective impedances of dividers I, II, respectively.
C_x and R_x—are added components to maintain initial O.C. voltage distribution.

Fig. 3—Suggested circuit arrangement for adjusting the impedances across the two breaks

Suggested Method for Accuracy in Recording

Balancing of Potential Dividers.—The following method is based largely on two facts :

(i) In the form of investigation under discussion, absolute values (i.e. absolute values of voltages appearing across the series gaps) are not so important as the ratio between them.

† "Natural" voltage division means here, that division which would obtain in the absence of any recording apparatus.

(ii) If the voltage ratio of the resistance-capacitance potential divider is the same for two different forms of applied voltage, e.g. two different frequencies, the ratio will be the same at all frequencies, i.e. the dividers will be balanced.

The method also arranges for the settings for the potential dividers and balancing components to be made on the actual circuit and at the voltages which are to be used in the investigation. The circuit arrangement is generally as shown in Fig. 3, except that C_x, R_x are omitted, and both dividers are connected across R_1. The test circuit comprises the normal test generator, and the three components R_1, R_2 and C_1 are disposed as shown. It is necessary only that the ratio R_1/R_2 be known accurately, although it may be simpler to make R_1 and R_2 equal.

Capacitance C_1 should be large compared with the total capacitance, including leads and dividers, existing across the two breaks, and the impedance of C_1 at 50 c/s should be large compared with R_1 and R_2, " large " here being, say, twenty to fifty times at least. As an example, if the capacitance existing across the two breaks is, say, 0·001 microfarad, then C_1 could be 0·05 microfarad and $R_1 = R_2 = 1000$ ohms.

The source of voltage supply is excited with the make switch open. Closing the make switch, preferably at voltage peak, gives a record from each divider similar to that shown in Fig. 4.

If, as mentioned above, C_1 is large compared with the capacitance existing across the breaks, and the impedance of C_1 at 50 c/s large compared with R_2, then the voltage at first appearing across the breaks at the closing of the make switch will be near enough equal to the peak of the applied voltage $E_{r.m.s.}$, say, E_{max} peak, and, because of the initial steep-fronted nature of the voltage appearing across the two breaks, the voltages across the two arms of each divider will divide in inverse proportion to the capacitive components, and thus the ratio of the voltage recorded at the bottom of the divider to voltage E_{max} peak will give the divider capacitance ratio.

Referring to Fig. 4, the recorded trace, after the first voltage pulse, will fall, according mainly to the circuit constants R_1, R_2 and C_1, and then follow a sinusoidal form with a peak amplitude, say, E_{max} r.m.s., determined by the ratio of impedances across the breaks to that of the component R_2. If the impedance of the breaks and of C_1 at 50 c/s is large compared with R_1, then the peak of the r.m.s. voltage appearing across the two breaks in series will be $R_1/(R_2+R_1)E_{max}$ peak (assuming, of course, that the load imposed on the voltage supply does not materially reduce the voltage).

Further, voltages recorded across the lower arm of the divider are now influenced by the resistive components of the divider and adjustment of these components is made so

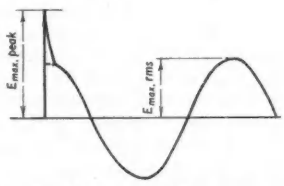


Fig. 4—Record obtained when make switch in Fig. 3 is closed

that the divider ratio for E_{max} r.m.s., is the same as that obtaining under the impulsive voltage E_{max} peak.

Where the conditions mentioned above concerning the relative values of R_1, R_2 and C_1 and the required regulations of the voltage source are met, little error need be introduced in obtaining balanced dividers. Where, for one reason or another, these conditions are not satisfied, it is necessary to determine the ratio of E_{max} peak to E_{max} r.m.s., and this is most simply attained by recording the voltage across the condenser C_1. For this, a simple capacitive divider is all that is necessary, and its ratio need only be known approximately ; in fact, one of the dividers being balanced can be used initially in its unbalanced condition. The ratio E_{max} peak

to E_{max} r.m.s. will be given by the ratio of the peak values determined by this divider, of the r.m.s. voltage appearing before and after the make switch is closed. It is still essential, of course, for C_1 to be large compared with the capacitance across the breaks, but this requirement should not be difficult to meet.

Where a d.c. source is available, such, for example, where energy is supplied from a charged condenser,[3] R_1 and R_2 can be large, and C_1 small in value, in which case a record as indicated in Fig. 5 will be obtained.

Adjustment of Impedances Across the Two Breaks.—A similar technique to that above is used to adjust the impedances across the breaks. The arrangement of circuit and dividers of Fig. 3 is used in which divider I measures the voltage across both breaks, whilst divider II measures the voltage across the lower break *B*. The volts across break *A* are given by the difference of voltage between the two dividers.

The components C_x, R_x across the top break *A* are added components to counteract, so far as voltage division is concerned, the disturbing influence of the divider across break *B*. Here, again, the aim is not to determine directly the values of C_x and R_x, but, by a similar procedure to that used for balancing the dividers, to adjust C_x and R_x so that the required distribution between the

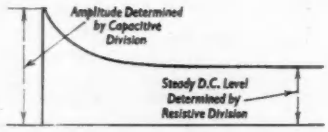


Fig. 5—Voltage record obtained using circuit of Fig. 3 when source voltage is direct current

breaks is obtained. C_x is adjusted on E_{max} peak (Fig. 4) and R_x is adjusted on E_{max} r.m.s.

Determination of the Natural Open-Circuit Voltage Distribution Between Series Breaks.—When setting up the recording apparatus it may be desirable to maintain the natural distribution of open-circuit volts between the breaks, and it is therefore necessary to determine this distribution. The following shows how the methods described above can be extended to make the required measurements.

It is required to determine the ratio 'volts on break *A*/volts on break *B*' for the transient and steady state conditions, and this ratio=Z_a/Z_b, where Z_a and Z_b are the impedances of breaks *A* and *B* respectively. The circuit of Fig. 3 is used with C_x and R_x omitted and operated as previously described. If the voltage across divider I is V_0 and that across break *B* given by divider II is V_1, then :

$$\frac{\text{volts on break } A}{\text{volts on break } B}=\frac{V_0-V_1}{V_1}=\frac{Z_a}{Z_b+Z_2}=R_1, \text{ say} \quad \ldots\ldots (1)$$

where Z_2 is the impedance of divider II across break *B*.

If the experiment is repeated, but the dividers (and leads) interchanged,

$$\frac{V_0-V_2}{V_2}=\frac{Z_a}{Z_b+Z_1}=R_2, \text{ say} \quad \ldots (2)$$

where V_2 is the voltage now appearing across breaks *B* (and now given by divider I) and Z_1 is impedance of divider I.

Similarly, with both dividers connected across the break *B* :

$$\frac{V_0-V_3}{V_3}=\frac{Z_a}{Z_b+Z_1+Z_2}=R_3, \text{ say} \ldots (3)$$

where V_3 is the new voltage across break *B*.

Assuming that V_0 is the same for the three experiments, from equations (1), (2) and (3) we have :

$$\frac{\text{volts on break } A}{\text{volts on break } B}=\frac{Z_a}{Z_b}=\frac{R_1R_2R_3}{R_2R_3+R_1R_3-R_1R_2},$$

or inversely,

$$\frac{\text{volts on break } B}{\text{volts on break } A}=\frac{Z_b}{Z_a}=\frac{1}{R_1}+\frac{1}{R_2}-\frac{1}{R_3}.$$

Two values for the ratio Z_a/Z_b will be obtained, one for the transient state and one for the steady r.m.s. state, and, referring back to the section on "adjustment of impedances across the two breaks," if these ratios are to be maintained, C_x (Fig. 3) will be adjusted to give the ratio Z_a/Z_b for the transient state and R_x adjusted on the steady r.m.s. state.

It will be noted that, under the transient state, Z_a and Z_b will be determined by the capacitive impedance in which case the ratio of the capacitances, C_a of break *A*, and C_b of break *B*, will be given by

$$\frac{C_a}{C_b}=\frac{1}{R_1}+\frac{1}{R_2}-\frac{1}{R_3}.$$

The ratio of the break resistance r_a/r_b cannot, however, be determined from the steady r.m.s. state unless the effective capacitive impedances at 50 c/s can be neglected. If, however, direct current is applied to the circuit (Fig. 5),

$$\frac{r_a}{r_b}=\frac{Z_a}{Z_b}$$

for the steady state direct current.

The most accurate results using the above method will be obtained when the impedances across each break is of the same order as the impedances of the dividers, which is a condition likely to be met in practice.

There are other ways, of course, of making a series of measurements with different capacitances or resistances across the breaks from which the required ratios of capacitance and resistance existing across the breaks can be deduced, but the above method uses the minimum amount of equipment and needs the simplest connections. Where there are more than two breaks in series, it is possible from a series of measurements to deduce by algebraic computation the required ratios.

In the case of three breaks, *A*, *B* and *C*, for example, by measuring first across the lower break *C*, the voltage ratio :

$$(\text{break } A+\text{break } B)/\text{break } C$$

can be determined in the manner outlined above, then by measuring the voltage appearing across the lower two breaks *B* and *C*, the voltage ratio,

$$\text{break } A/(\text{break } B+\text{break } C)$$

can be determined, from these two ratios the voltage ratios break *A*/break *B*/break *C* may be deduced.

A similar procedure can be adopted for any number of breaks in series.

It will, however, be appreciated that, when measurements are made across a number of breaks in series, the effective impedance of these breaks becomes higher, and thus the potential dividers will need to have proportionately higher impedances if accuracy is to be maintained. Moreover, as the number of breaks increases, calculation becomes more intricate, and errors may become appreciable.

Probably a better method, where more than two breaks in series are concerned, is to short out all but two of the breaks at a time, and obtain the voltage division between two breaks in turn, applying the appropriate reduced voltage. Thus, for example, with five breaks—*a*, *b*, *c*, *d* and *e* in series, if the voltage divides in pairs such that a/b, b/c, c/d and d/e are given by u, v, w and x respectively, the voltage division $a/b/c/d/e$ will be given by $1 : 1/u : 1/uv : 1/uvw : 1/uvwx$. This should be quite satisfactory providing that the effect of shorting breaks does not materially influence the capacitive division across the unshorted ones. A short direct connection between the electrodes forming the breaks, if this is possible, would no doubt meet this requirement.

Under laboratory conditions, the above requirements and the need for high impedance dividers are not difficult to meet, but where difficulty in these respects is met, then direct

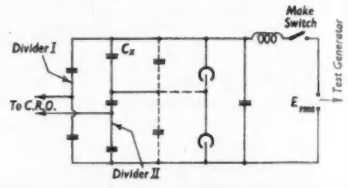


Fig. 6—Suggested circuit arrangement when simple capacitive dividers are used

measurement of the parameters associated with the breaks is probably best made by the use of suitable bridges.

The high-voltage Schering bridge (treated in many textbooks, one by Hague[4] being an example) can give quite accurate results,[5] but where the capacity of a break having neither electrode at earth is to be measured, then the inductively coupled double-ratio arm bridge is perhaps to be preferred,[6] although measurements with this form of bridge can only be made at low voltages.

Simplification of Methods when Purely Capacitive Dividers are Used.—Where dividers of a purely capacitive nature are used, a normal test circuit can be used as shown in Fig. 6. Operation of the circuit as previously described will give records similar to that of Fig. 7, which, incidentally, will be a record of the restriking voltage transient if the series resistance in the test circuit is zero, i.e. if the power factor is zero. The divider ratio can be checked or obtained from E_{max} r.m.s. if it is known and a check that a capacitive divider is suitable will be afforded by the

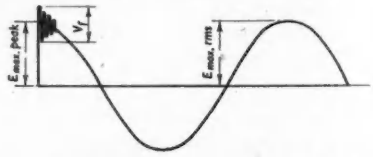


Fig. 7—Record obtained when make switch of Fig. 6 is closed

fact that E_{max} peak and E_{max} r.m.s. should be recorded equal.

For determining the natural voltage division between the breaks, the ratios R_1, R_2 and R_3 (equations (1), (2) and (3)) can be obtained from E_{max} r.m.s.

It should be noted that if the divider capacitance is small compared with the total circuit capacitance, then V_f should have the same proportionality to E_{max} r.m.s. for the three experiments of the previous section, in which case a further check on the suitability of using capacitive dividers alone can be obtained, since the voltage distribution determined from E_{max} r.m.s. should be the same as that determined from V_f.

Conclusions

From the foregoing it will be seen that, because of the large number of components involved in the necessary recording apparatus and associated circuit arrangement for

investigating the division of restriking voltage between breaks in series, it is possible for comparatively small discrepancies in their individual values to accumulate and give rise to inaccurate results. Recording potential dividers may influence the manner in which the voltage divides between the breaks, and thus the impedances of the dividers should be kept as high as possible and their presence not overlooked.

By taking advantage of the fact that the ratios of the voltages existing across the breaks is of more importance than the actual values of voltage, it is possible, as outlined above, to set up simple apparatus in a manner which ensures that, on the test circuit itself and at test voltages, errors due to recording apparatus are kept to a minimum.

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International Railway Congress, 1954*

No. IV—(*Concluded from page 864, June 11th*)

Certain engineering aspects of the discussions on "Way and Works," and "Locomotives and Rolling Stock" sections are summarised here. Generally the question of permanent way maintenance involves problems as much of personnel as of engineering. Means for improving the efficiency of steam locomotives were discussed, but against a background of gradual replacement by other forms of motive power.

Mechanisation of Permanent Way Maintenance

MUCH of the discussion and points covered in the summaries of this question concerned administrative problems relating to the personnel of the permanent way gangs, and there were naturally many differences to be noted, not only between one country and another but in different districts within the areas served by a single railway. The application of mechanical methods was originally based to a large extent upon previous experience of the durability of the work in different districts, and upon careful examinations on site. In addition there are inevitably times when trouble actually appears in the track, though by then the defects may be so far developed that they are beyond repair, and complete renewal is therefore necessary. It was generally recognised, however, that what the Congress chose to call "the stitch-in-time" method is inadequate, and that nowadays maintenance programmes are no longer based on simple estimates of the actual condition of the track. To-day estimates are made of the probable rate at which it will wear, and programmes are scheduled accordingly.

The economics of mechanised maintenance of the track raise some interesting points. If the large modern items of equipment (such as the Matisa ballast cleaner, or the large track-laying machine shown in the Willesden exhibition) are to be used to the greatest advantage long gaps in the running of trains is desirable—that is if "absolute possession" cannot be provided. If long, clear periods are available the relaying operations can be speeded up; the expense of all services concerned is reduced, and not least the expense of slowing up all traffic passing over the line. In passing it is very interesting to note that the Congress regarded the slowing-up of traffic not merely as an inconvenience but as an expense. This is a feature of present-day operating that cannot be too strongly emphasised. The use of recording vehicles was commended, particularly those which give the position of each rail in the vertical and horizontal planes, and the exact gauge of the rails. By the comparison of successive readings these vehicles make it possible to follow the evolution of the condition of any given line. With such records available it is possible to arrange for maintenance work to be done at the right place and the right time, having consideration of the track standard of the railway system concerned. In general it was agreed that mechanisation yields a large increase in individual output, though the saving on the work as a whole is less. The saving decreases very rapidly when the amount of work to be done is small, and when the traffic on the line in question is considerable. It requires careful predetermination of the work to avoid useless operations.

The general application of the new methods would, it was considered, only be crowned with success when the managerial staff was so trained that it knew the possibilities and limitations of these methods as well as its own role in the economies which must result from their application.

* Held in London, May 19th to 26th.

Wear of Rails on Curves

This subject was discussed in that section of the Congress dealing with light railways and Colonial railways, but the report presented in response to Question 10 really had considerably wider implications than those existing on Colonial railways. In this report consideration was given to the influences of certain aspects of the rolling stock in use, for example, play of the axles, resistance in bogies and bissel trucks, position of loads, and so on. In particular, special attention was given to effects of the operation of locomotives and rail motor coaches with driving bogies. While some administrations have not noted any harmful effects others consider them to be particularly "aggressive" and to produce lateral rail wear which is much heavier than that caused by carrying bogies or by certain long-wheelbase vehicles. These effects, on the railways concerned, are attributed to the amount of the axle-load and especially to the unsprung mass, in the case of nose-suspended traction motors; they are also attributed, in part, to increased rates of acceleration, and to speed, and to asymmetrical motor couple.

Methods used to overcome, or to counteract such troubles are: a reduction in the widening of the gauge on curves, together with modification of the superelevation; laying of a check rail along the inner line; use of rails with a high resistance to wear; and lubrication of the rails. Of these methods, the reduction of gauge widening has been carried out with the idea of lowering the angle of thrust and reducing oscillation. At the same time, attempts have been made to achieve a closer relationship between superelevation and operating speeds: on most lines the latter would be difficult to attain, due to the wide variation existing between maximum and minimum speeds. The use of a check rail is primarily a safety measure on sharp curves, and so far as the motion of the train is concerned it is something of a handicap, causing supplementary wear on the inner surface of tyres. In any case, it increases the expense. High cost is also a factor weighing heavily with some administrations against the use of rails with a high resistance to wear—high manganese steels, or heat-treated steels. By contrast rail lubrication can be generally applied with relative simplicity. There are various well-recognised ways of applying such lubrication. Manual application limited to special cases, because of the labour cost involved, must be carefully done to avoid the spread of oil on to the running surface. On the other hand, several kinds of fixed lubricators and equipment mounted on motive units or trailer vehicles provide a satisfactory regularity of operation. The use of lubricators fixed to the rail at the entrance to curves, worked by the passage of each wheel, is particularly justified on isolated curves of low radius, or where the curves are relatively few in number. When electromagnetic brakes are used these lubricators have to clear the gauge, and the Congress expressed a wish to have this gauge defined. To sum up: rail lubrication provides a very efficient means of reducing not only their lateral wear but also tyre wear. The life of rails is, in certain cases, almost doubled.

Improving Steam Locomotive Efficiency

The special reporter, Monsieur R. Squiblin, of the Belgian National Railways, opened his statement by recalling that the same question was put to the Congress of 1937, and by emphasising what a marked change had come over the status of the steam locomotive since then; at that earlier Congress Sir Nigel Gresley was the special reporter. As Dr. Diegoli, of the Italian State Railways, said in his particular report for the present Congress, "the steam locomotive had reached a full and brilliant condition of maturity, following a period of some ten years of intense development. . . ." "Now," he continued, "its future is debatable and limited in time." The special report discussed by the Congress was compiled as a result of replies from less than twenty administrations. Some excused themselves from replying on the grounds that circumstances have precluded them from sparing the time and personnel required to deal with the questionnaire. British Railways, in the throes of yet another reorganisation, fall within this latter category; but while the replies came from a limited field some of these were very fully documented, and the full report of Mr. C. T. Long, in the *Congress Association Bulletin* for January, 1954, and that of Dr. Diegoli, in the *Bulletin* for April, 1954, contain replies from such countries as France, Germany, Belgium, Spain, India, Ceylon, Victoria and South Africa. With the qualification that the field of inquiry was limited to those countries the summaries eventually agreed—an interesting reflection upon the trend of the times. While no reply to the questionnaire was forthcoming from this

country, British delegates took a prominent part in the discussion.

The summary at the end of Monsieur Squiblin's special report opened with the plain statement : " Steam traction is being progressively displaced by other forms of traction, and little new steam locomotive construction is now envisaged." In view of the size of the stock of steam locomotives that will have to remain in service for many years to come the principal aim of most railways concerned, however, is to reduce to a minimum the cost of operation, and to increase the availability of engines by improved efficiency of performance and especially by simplification. It would appear that in the search for a lower operating cost for steam traction, in the present state of steam locomotive technique particular attention should be paid, without any cessation of the search for technical improvement in the motive unit, to improving the organisation of the locomotive's service (operation and maintenance).

In view of the extensive work undertaken recently on British Railways to combat the effects of inferior grades of coal, it is rather noticeable that in the special report to the Congress, compiled from the replies of some twenty administrations to the questionnaire circulated, there is no reference to any present-day difficulties in the obtaining of suitable coal for locomotive firing. A delegate representing the British Ministry of Fuel and Power did suggest, in the discussion, that the experiences which had been gained in various countries in the use of pulverised coal firing with stationary equipment could be applied to steam locomotives without any great difficulty ; but it was pointed out that locomotive experience with pulverised coal had not given satisfactory results and such experiments had been discontinued.

As regards the future of steam traction, while in France, as in the U.S.A., it is probable that very few further steam locomotives will be built, and that in other countries the slowing of new construction is much in evidence, it would seem that the summary quoted earlier is rather sweeping in its conclusion, seeing that increasingly large and powerful steam locomotives of the Beyer-Garratt articulated type are being built in this country for a variety of arduous duties overseas, and that the Indian Government Railways is planning to build large main line locomotives using the high boiler pressure of 284 lb per square inch. It would have been extremely interesting to have had the experience of the Rhodesian Railways embodied in one of the reports, because on that system the utilisation of Beyer-Garratt locomotives is maintained at an unusually high level, and the mileages run are somewhat exceptional in view of the necessarily low average speeds of both passenger and freight trains.

In the summary on the report it was stated that annual mileages of locomotives have been considerably increased and now attain 50,000 to 56,000 miles ; this, it was stated, was due to the development of multiple crew services, double or triple crews, and even completely common usage. Several delegates, however, pointed out that multiple manning was not the only factor contributing to this improvement. Improved maintenance methods and simplified mechanism also played a considerable part, while so far as mileages were concerned several instances were quoted of annual mileages between 70,000 and 100,000.

It is certainly very difficult to generalise on such a subject as annual mileages, as they depend so very much upon local conditions, on the convenience of the timetabled trains, and in many cases on the personal enthusiasm of the district officers, or even the shed-masters concerned.

An interesting section of the report compiled by Mr. C. T. Long concerned the experience of the Indian Government Railways and of the South African Railways with mechanical stokers. In South Africa it has been shown that combustion efficiency when hand firing is far superior to mechanical firing under ideptical working conditions. In India the same tendency has been noted, and quantitative results are quoted from dynamometer car trials carried out on " Pacific " locomotives of the " XE1 " class. The differences in favour of hand firing is of the order of 5 to 8 per cent, and the Indian Railways quote the following points as contributing to this efficiency :—

(1) Insufficient furnace volume resulting in carrying over of unburnt slack and dust.

(2) Lack of secondary air above fuel bed.

(3) Excessive loss of slack through fire bed due to rocking of grates.

(4) Steam used for stoker operation.

Nevertheless the tendency is for mechanised firing to be increasingly used, particularly where the coal rate approaches the limit for hand firing. The experience of higher coal consumption with mechanical firing is much the same on the Continent of Europe, though it is generally agreed that its use allows fuel to be used which is not very suitable for hand firing.

Other points brought out in the final agreed summary on this question were :—

(*a*) No new tendency has been shown in recent years with regard to the various kinds of exhaust used on steam locomotives. Variable exhausts tend to disappear.

(*b*) Cylindrical piston valves with Walschaerts gear prevail, by reason of their simplicity and ease of maintenance. Poppet valves are used only in special cases.

(*c*) Despite the thermodynamic advantages which may result from the adoption of compounding, there appears to be a very clear tendency in favour of simple expansion because of the greater simplicity of the mechanism.

(*d*) Air preheating, condensers and thermic siphons are little used and in all cases only in special circumstances.

In conclusion, the present position and tendencies of some individual railways will be of interest. The French National Railways, having a present stock of more than 10,000 steam, 1000 electric and about 150 diesel, does not intend to build any more steam locomotives. Electrification is to be extended, the use of diesel locomotives for shunting and railcars for feeder services to be increased, and it is considered that the present steam stock will be adequate for the gradually lessening requirements. In Germany, several new designs of steam locomotive are in hand, though the ultimate aims seem much the same as those of France. The present Indian position is interesting, as the electrification of some lines there took place at a relatively early date. On March 31, 1951, this Administration had 8120 steam locomotives, 17 diesel-electric shunters and 72 electric locomotives. Future developments in India are likely to be the electrification of certain lines with dense traffic, electrification of suburban services around Calcutta, and the extended use of diesels for shunting. In spite of these developments the administration considers that steam locomotives will provide 85 per cent of the traction for the next twenty years. On the South African Railways, while no general forecast of the future was forthcoming, the present position is given in the table.

South African Railways' Locomotives

	Number in service	Number on order
Steam locomotives ...	2506	260
Electric locomotives ...	236	89
Diesel locomotives ...	2	—

No account of the purely technical proceedings of this Congress, however, can convey the friendly atmosphere and readiness to contribute experiences expressed on all hands. To this end the work of the British Organising Commission contributed in large measure.

Birthday Honours

THE Queen's Birthday was officially celebrated on Thursday, June 10th. A Birthday Honours List published on that day includes the following awards :—

Knights Bachelor.—Colonel J. G. B. Beazley, chairman, Mersey Docks and Harbour Board ; Mr. R. R. Costain, chairman and joint managing director of Richard Costain, Ltd.; Mr. A. A. Hall, director of the Royal Aircraft Establishment, Farnborough ; Alderman P. A. Sanders, deputy chairman of Davey Paxman and Co., Ltd.; Mr. Frederick Scopes, president of the Joint Iron Council, and a managing director of Stewarts and Lloyds, Ltd.; Mr. F. E. Simon, Professor of Thermodynamics, Oxford University ; Professor A. R. Todd, chairman of the Advisory Council on Scientific Policy ; Major A. H. S. Waters, V.C., chairman of the South Staffordshire Waterworks Company ; Mr. Ian Clunies-Ross, chairman of the Scientific and Industrial Research Organisation in Australia.

C.B.—Rear-Admiral (E) Charles Littlewood ; Major-General W. A. Lord, Corps of Royal Electrical and Mechanical Engineers ; Major-General R. K. Millar, late Corps of Royal Engineers ; Mr. H. S. Pengelly, Principal Deputy Director of Naval Construction, Admiralty ; Mr. W. A. Wolverson, director, External Telecommunications Executive, G.P.O.

K.C.M.G.—Major-General L. B. Nicholls, chairman, Cable and Wireless, Ltd.

C.M.G.—Mr. Ivor Bowen, Principal Director of Equipment Research and Development (Air), Ministry of Supply ; Mr. Graham Morgan, Director of Public Works, Tanganyika.

K.B.E.—Rear-Admiral (E) A. D. McGlashan ; Mr. I. A. R. Stedeford, chairman and managing director of Tube Investments, Ltd.; Sir Arthur C. Griffin, lately chairman of the board of the Rhodesia Railways.

C.B.E.—Rear-Admiral (E) R. W. Parker ; Mr. F. J. Colvill, Engineer-Surveyor-in-Chief, Ministry of Transport and Civil Aviation ; Mr. W. J. Everard, director of F. T. Everard and Sons, Ltd.; Mr. T. E. Goldup, director of Mullard, Ltd.; Mr. G. C. Grove, Deputy Civil Engineer-in-Chief, Admiralty ; Mr. F. H. Harrison, Director of Equipment and Stores, Ministry of Supply ; Mr. H. G. Herrington, managing director of High Duty Alloys, Ltd.; Dr. W. Idris Jones, Director-General of Research, National Coal Board ; Mr. V. A. Pask, chief engineer, headquarters, British Electricity Authority ; Mr. A. E. Russell, director and chief designer, Bristol Aeroplane Company, Ltd.; Mr. Jack Tanner, lately president of the Amalgamated Engineering Union ; Mr. Harold Tongue, for services as chief engineer, Atomic Energy Research Establishment ; Mr. B. B. Winter, director of engineering, Rootes, Ltd.; Mr. S. J. W. Gooch, chief civil engineer, Crown Agents for Oversea Governments and Administrations ; Mr. I. B. Trevor, general manager, Hong Kong Railways.

PROCEEDINGS OF THE NORTH SEA FLOOD CONFERENCE.—The Institution of Civil Engineers has now published a volume containing the papers submitted at the conference on the North Sea floods, held last December, together with a report of the oral discussion. The papers cover the flooding in all its aspects, including the causes, effects and the measures taken to endeavour to prevent a recurrence. The volume costs 25s., post free, and may be obtained upon application to the secretary, the Institution of Civil Engineers, Great George Street, Westminster, S.W.1.

Locating Steel Reinforcing Bars in Concrete Slabs

By A. C. WHIFFIN, M.Sc., Ph.D., A.M.I.Mech.E.*

During the past twenty to thirty years, radiographic methods have been developed for detecting flaws in metal structures, mainly employing X-ray apparatus and, since the recent war, radioactive isotopes emitting gamma radiation have begun to be employed in this work. X-ray radiographic methods have been used to detect the position of the bars in reinforced concrete,[1] but the X-ray equipment is expensive and not usually very suitable for use on the average civil engineering site. The radiographic technique described in this article employs equipment costing less than £20 and its operation is quite simple.

THE radiographic method described in this article was developed at the Road Research Laboratory to locate the position of the steel reinforcing bars in two pieces of concrete before cores could be cut for determining the compressive strength of the concrete. Each piece of concrete was 23in by 13in by 6in and a steel bar of $\frac{5}{8}$in diameter could be seen in one of the 13in by 6in faces and two bars of similar diameter in one of the 23in by 6in faces (see Fig. 1). It was suspected that the first bar ran parallel to the 23in by 6in faces and that the pair of bars joined it and were hooked. If this were true, core cutting would have been simplified because bars of the type described seriously hinder such operations.

The steel bars were roughly 3in below the 23in by 13in faces of the slabs and it was

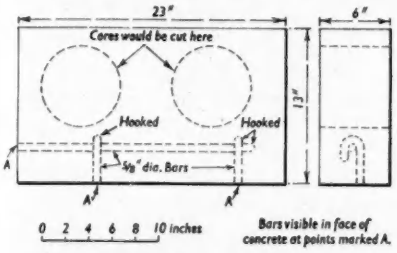


Fig. 1—Details of concrete slab showing suspected position of reinforcement

found impossible to detect their position electromagnetically. The ultrasonic pulse technique was also tried,[2] since it was expected that a change in the velocity of ultrasound would occur when the vibrations were propagated through the steel instead of solely through the concrete. This technique failed, probably because of the relative dimensions of the steel bars, the transmitter and receiver, and the large aggregate (between 1in and 2in) of which the concrete was composed.

Preliminary Measurements by a Radioactive Technique

An attempt was made to survey the slabs by measuring the intensity of the gamma radiation emerging from the rear face of the slab when a radioactive source was placed near the front face.

In connection with experiments to measure the change of density with depth in concrete road slabs compacted by a surface vibrator,[3] the Laboratory has a radioactive source (supplied by the Atomic Energy Research Establishment, Harwell) consisting of a piece of radiocobalt 14mm in diameter by 14mm long contained in a brass cylinder and housed in a lead castle (see Fig. 2). The source has an energy of 100 millicuries and this will diminish to half strength in 5·3 years. A Geiger-Müller tube held in a lead collimating tube and connected to pulse-counting equipment is used for measuring the intensity of radiation. If it may be assumed that steel and concrete absorb gamma radiation in proportion to their respective densities, then it can be shown theoretically that the intensity of radiation emerging from a 6in slab at a point where the rays pass transversely through a $\frac{5}{8}$in diameter steel bar will be only 16 per cent of that emerging when the rays pass solely through 6in of concrete. Since the bar was $\frac{5}{8}$in. in diameter and the lead collimating tube had an internal diameter of 1in, the intensity of radiation actually recorded when the rays passed through the steel should have been about 70 per cent of the intensity where there was no steel. Measurements made using the arrangement shown in Fig. 2 gave pulse counts of 2500 per fifty seconds when the rays passed only through the concrete and 2000 when they passed through a reinforcing bar. This change of 20 per cent compared, with the theoretical value of 30 per cent, may have been due to slight misalignment of the source, bar and collimating tube, and also to the fact that the radioactive source had a finite size and was not infinitesimally small as was assumed in the calculations.

It was clear that the technique described was not sufficiently sensitive to locate accurately the position of the bars and that a complete survey of the slabs by the method described would be laborious and would have necessitated building a frame to keep the equipment aligned on the source together with lead screening to protect the operator, who would need to remain near to the source to make the fifty-second counts. The preliminary experiments indicated, however, that a change of intensity of the emergent radiation occurred when the gamma rays passed through the steel bars and that a radiographic method would probably give the required information. It must be mentioned that the equipment necessary to measure the intensity of gamma radiation costs about £300 and is not usually built in a sufficiently robust form to be used on civil engineering sites.

Radiographic Experiments

The broad details of the experimental arrangement are shown in Fig. 3. The 100-millicurie radioactive source was placed $4\frac{1}{2}$in in front of one of the 23in by 13in faces of the concrete slab. This distance was held constant to facilitate any geometrical drawing needed to locate the position of the bars from the shadows recorded photographically and also to keep the time of exposure constant.

The piece of radiocobalt in its container was held on the end of a rod passing axially through the lead castle in which it was carried to the site. The castle was placed on its side with its thick steel base removed, and the rod was adjusted so that the source just protruded from the castle and the lead did not cast shadows on the photographic film. Lead bricks were placed around the source, as shown in Fig. 3, to minimise the health hazards. The adequacy of this shielding was checked by personal monitors carried by the operators. The precautions taken in this work were perhaps rather excessive, because, as is now well known, the risk to health arises from the duration of the

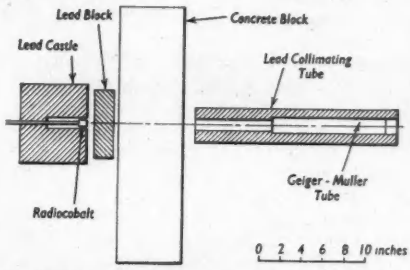
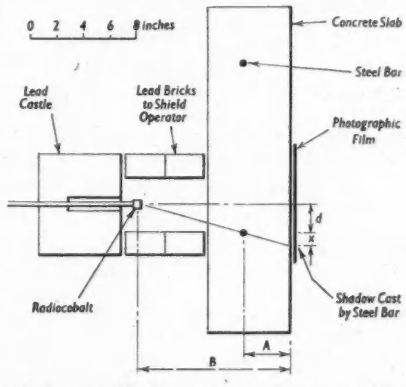


Fig. 2—Experimental arrangements for preliminary attempt to locate steel bars by measuring intensity of gamma radiation emerging from slab

exposure as well as from the strength of the radiation, and, in this work, the operators only needed to be near the equipment for about five minutes every two hours.

The gamma-ray photographs were taken on Ilford Industrial Type G X-ray film, which is suitable for working with gamma sources both with and without lead intensifying screens in front and behind it. The film was supplied in pieces each $8\frac{1}{2}$in by $6\frac{1}{2}$in ; one piece at a time, contained in a black paper



x=Displacement of shadow of bar on film due to oblique incidence of gamma ray.
d=Distance of true position of bar from centre line joining source to centre of film.

$$d=x\left[\frac{B}{A}-1\right]=\left[d+x\right]\left[1-\frac{A}{B}\right].$$

Fig. 3—Arrangement for locating position of reinforcement by gamma radiography

envelope to protect it from daylight, was attached to the rear face of the slab by adhesive tape (see Fig. 3). For each exposure the source and the centre of the film were approximately aligned. The rear face of the slab was marked out in areas each a little smaller than a piece of the film, and photographs were taken with a piece of film in each area in turn. On this occasion, to minimise the work involved, the source was kept in a fixed position and the concrete slab was moved on a trolley so that the whole of it could be explored. This would not be possible in testing a concrete structure ; the source would need to be slung in some way near one face while pieces of film were attached to the rear face roughly opposite the source. As shown later, it would be essential in such a case to keep accurate records of the position of the source and film.

When the work began there was no information available concerning the length of

* Road Research Laboratory, Department of Scientific and Industrial Research.

exposure needed to give satisfactory photographs. Experiments were made with a piece of film in an area of the concrete where it was known that one of the steel bars was present and an exposure time of two hours was found satisfactory. The films were processed in the dark, having five minutes in Ilford Developer Type ID.33. A positive print reproduced from one of the pieces of negative film is shown in Fig. 4.

In the present work the depth of the bars below the surface was known and their

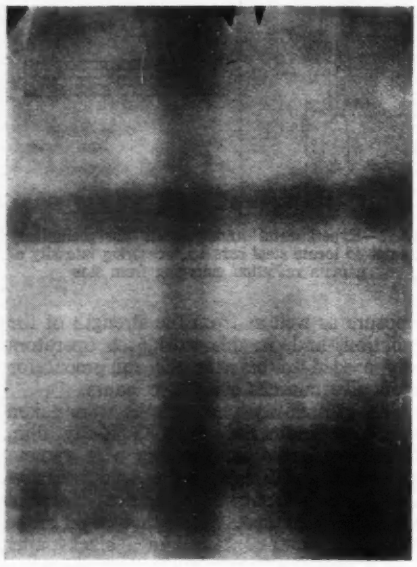


Fig. 4—Positive print showing positions of reinforcing bars

precise position was found from their shadows on the films by simple geometry, as indicated in Fig. 3. If, as will probably occur in testing a structure, the depth of the bar is unknown, two separate photographs must be taken at each test area of the rear face of the concrete with the source in different positions for each exposure. The position of the steel bar can then be found graphically.

Fig. 5 shows the actual position of the bars in one of the slabs. The two bars

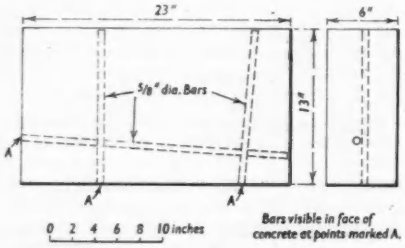


Fig. 5—Details of concrete slab showing actual positions of reinforcement

visible in the 23in by 6in face did not terminate at the other bar, as had been thought to be the case, but continued until they nearly reached to the opposite face. Moreover, these two bars were not parallel but diverged as shown. Both slabs have since been cut up and measurements have shown that the steel bars were precisely in the positions indicated by the radiographic work.

Comments

The apparatus employed in the radiographic technique is not expensive. A piece of radiocobalt of strength of about 100 millicuries can be obtained from the Atomic Energy Establishment, Harwell, for about five guineas. The lead castle is little more than a thick-walled lead cylinder with the lead contained between two concentric steel tubes for ease of manufacture. The rod carrying the small cylinder containing the source slides in the inner steel tube. Provided the operators take care never to be exposed to the direct radiation from the source, by using the castle itself and a few lead bricks for shielding, there is little risk to health. A number of authorities in Great Britain are available for giving advice on protection against radiation.

The application of the method to thicknesses of concrete exceeding 6in would probably require stronger radioactive sources, although, using a source of strength of 100 millicuries, as in the present work, thicknesses somewhat greater than 6in might be studied by increasing the exposure time beyond the two-hour period. It must be stressed that the success of the technique depends not only on the source being sufficiently strong to give satisfactory photographs on film placed on the other side of the specified thickness of concrete, but also on the difference in thickness of the steel bar and the concrete.

The experiments described in this article had to be done quickly because the slabs were urgently required, and there was not time to explore the lead screen method of intensifying the images formed on the film. Under certain conditions, placing the film between two thin layers of lead during exposure to gamma radiation gives about double the photographic intensity and permits the time of exposure to be approximately halved. This technique should be tried in cases where success is not easily obtainable by the method outlined in this article.

Acknowledgments

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British Electrical Power Convention

PRESIDENTIAL ADDRESS

By J. R. BEARD, C.B.E., M.Sc., M.I.C.E., M.I.E.E.

The British Electrical Power Convention opened on Tuesday last, at Eastbourne. After a civic welcome by the Mayor, the presidential address was delivered by Mr. J. R. Beard, who explained the functions of the consulting engineer and the contribution that the consultant can make to the promotion of electrical development at home and overseas. Abstracts from the president's address are reproduced here.

MODERN developments have tended to divide consulting engineers into three categories: first, individuals prepared to advise on unusual technical problems of which they have specialised knowledge; second, firms of small or medium size particularly concerned with electrical installations for industrial concerns and large buildings, and third, a comparatively few firms with large staffs dealing with the largest schemes who, in view of their size, are in a position to employ the highest grade of specialist staff in all branches of their work, fully comparable in technical training with the design staffs of the largest public bodies and with the added advantage of experience of a wider range of work at home and overseas. Such firms are fully competent to take responsibility on behalf of their clients for even the largest scheme from the initial project stage through its construction until it is completed and commissioned. Moreover, since by long-established British practice the client himself places the actual orders and makes the actual payments to contractors, consultation between him and the consulting engineers arises naturally at all important stages.

Contribution of the Consulting Engineer to Overseas Trade

The work of the smaller firms is most valuable in their special fields, but it is the large firms in the third category which can be most helpful to this country in the expansion of its overseas trade and influence and, as the nature and extent of such help is by no means as widely appreciated as it should be, I hope you will allow me to refer to this at some length. The help possible from the medium-size firm in the industrial field may also be appreciable and has, perhaps, not been as actively employed as it should be.

The fees earned from overseas work are themselves a valuable invisible export and, while small compared with our engineering exports as a whole, it should be remembered that there is no cost of imported materials which needs to be set off against them. However, the more important value to the country of the overseas activities of consulting engineers is undoubtedly the widely recognised fact that they constitute the spearhead of the engineering export trade. I must, however, hasten to add that this is sometimes rather thoughtlessly taken to imply that a British consulting engineer is expected to place his contracts with British contractors. This is certainly not the case—British contractors know that their tenders will not be recommended unless they are most advantageous to the client, but they also know that they can rely on unambiguous specifications and impartial adjudication of tenders. It cannot be over-emphasised that the tradition of British consulting engineers is that they act in the interests of their clients and that they have no hesitation whatsoever in recommending the placing of contracts anywhere in the world if, when all things are taken into account, this should be to the benefit of the client. It will be appreciated, of course, that the client's overall interests frequently depend on many factors other than price, technical design and delivery, as, for example, facilities for providing spares and undertaking repairs, and the previous experience of the tenderer in undertaking work of a similar character and under similar conditions.

Unless this position is made abundantly clear to prospective overseas clients the

inevitable result will be to undermine the confidence in the consulting engineer which is so essential in the carrying out of large projects abroad. In the client's interests the designs and specifications should be such as to ensure that requirements are not only adequately defined, but that, where world tenders are to be invited, unnecessary restrictions are not introduced which might tend to handicap any responsible tenderers, whatever their country. Such carefully prepared designs and specifications are equally in the interests of the tenderers as they then know exactly what is required of them and can safely make keen quotations. It is also pertinent to refer to the well-established practice of British consulting engineers of recognising the right of the contractor to fair treatment in accordance with the terms of the contract while the work is being carried out.

Many overseas specifications are drawn in such a way as to make it difficult for British manufacturers to quote and it is my opinion that the chief value of British consulting engineering to British export trade should be to ensure for our manufacturers of plant and equipment a fair and proper consideration of their offers and, in so doing, to benefit the purchasers by extending the field of competition. If the true merits of British tenders are thus properly presented to the overseas client the consulting engineer's work will lead to increased British exports, provided, of course, that British manufacturers take advantage of the opportunity to demonstrate their competitive superiority.

Looking back over the years, I think Great Britain can justly claim both a wide experience of world problems and a reputation for realising the broad advantage to Great Britain itself of dealing with these problems with proper regard to the interests of the countries concerned. This experience and characteristic of the British people should enable them to make a significant contribution to the vast problems of raising the standard of living in wide under-developed areas of Asia, Africa and elsewhere. The United States, which is to-day the source of the larger part of the available capital for such developments, and whose people undoubtedly combine business acumen with a genuine desire to help mankind, is doing much to encourage projects in these under-developed areas and, I believe, in many cases is more ready than is sometimes realised to associate non-American manufacturers and consulting engineers with American-sponsored overseas projects.

The Under-Developed Countries

This world-wide emphasis on the problem of the under-developed countries is of great importance from several points of view. In the first place, by increasing the standard of living it is hoped to increase political stability and to spread peace-promoting conditions amongst peoples hitherto accustomed to living at subsistence levels which the industrialised countries began to leave behind nearly two centuries ago. This has become the more urgent since the advent of the cinema, radio, and air travel have spread widely the knowledge of the standard of living in the more developed countries.

In the second place, the knowledge of the fundamental principles of economics, though still woefully inadequate, has definitely increased and to-day it is generally accepted that an increase in the wealth and prosperity of one country is, at the least, not unbeneficial to the wealth and prosperity of its neighbours and of the world as a whole. No doubt politically we are a long way from a world state, but we inevitably tend that way economically. This being so, it is beneficial to the more developed countries to assist in advancing the agricultural and industrial activities of those less developed. Not only does it provide immediate oversea markets for their high-grade manufactures and technical skill, but it builds up by almost geometrical progression further international trade.

Broadly speaking, the wealth of any nation is in the skill, intelligence, initiative and capacity for hard and accurate work of its people. Many spheres of human activity contribute to increase these, but I think electrical engineers, by providing the power which is the mainspring of more efficient industry, agriculture and domestic life, can feel that they play a large part in creating the material conditions necessary for such increase. However, I would like to strike a note of warning about the difficulty of convincing under-developed countries that our desire to assist in these developments is as much in their own interests as in our own. We need to make it clear that this is one of those instances, which are commoner than is realised, in which both parties benefit. This is so even on the most mundane grounds, but, if we do ourselves justice, I think the Anglo-Saxon nations on both sides of the Atlantic do add a certain spiritual awareness of their duty to their neighbour. They are not always credited with this, but let us not be unduly discouraged or embittered if it often has to pass unrecognised.

In approaching under-developed countries it is necessary on the one hand to avoid undue emphasis on our own superior skill and knowledge and, on the other, to appreciate the natural desire of the engineers in such countries to do themselves such work as they think they are capable of doing efficiently. I would particularly stress the importance of ensuring that the Governments of under-developed countries, with their understandable pride in what is often very new-found freedom, should not feel that they are being exploited in the interests of the more highly industrialised countries when they are in reality merely being helped to solve problems for which they have not at the present time sufficient experience.

One thing which is perhaps brought home to a consulting engineer more directly than to a contractor is the difficulty of working with a client who does not give you his full confidence. It just leads to argument, delay, frustration and duplication. Hence the importance of preserving and cultivating that professional and ethical outlook of the British consulting engineer and endeavouring to get overseas clients to appreciate it and obtain its full benefit.

Factors Hampering Work Overseas

This reference to the professional and ethical outlook reminds me that early in my address I mentioned some aspects of British professional practice which were hampering our work in certain other parts of the world and to which I proposed to refer later. I had particularly in mind the veto which has always been placed on advertising and on soliciting work. There is no suggestion of any change of attitude for work in Great Britain, but there is a growing appreciation of the fact that a strict interpretation of this principle would make it extremely unlikely that British consulting engineers would receive many appointments in some countries overseas. Already some relaxation is permitted in Commonwealth countries in so far as their appropriate national engineering institutions permit and some similar extension to non-Commonwealth countries is overdue.

This is a matter which is continually being pressed upon the Association of Consulting Engineers by the Board of Trade, which has both a very keen appreciation of the value of consulting services and a vivid realisation from its officers overseas of the great handicaps which the rigid British professional code places upon British consulting engineers as compared with the much greater freedom allowed or at least taken by many corresponding firms from North America and the Continent. We are grateful to the Board of Trade for its support and its advice, but I am sure that what I have said about the value of our ethical approach indicates that on a long-term view any further relaxation should be made with caution. That, however, is no reason for shirking or delaying the discussion of the problem which is undoubtedly one of great importance to this country.

Financing Work in Under-Developed Countries

A most important factor in overseas electrical developments, and one by no means confined to under-developed countries in the accepted sense, is the means by which promising projects are encouraged through special arrangements for technical assistance and by loans. In both of these consulting engineers are directly concerned. They would seem to be the obvious source of technical assistance and the people who should do most to ensure that loans were properly spent. However, this does not appear to be as widely appreciated as it should be and it may be helpful, therefore, to review the main sources of such technical assistance and ideas.

Until the turn of the century Great Britain had been responsible for providing the major part of the capital for overseas development. The first world war severely restricted her capacity to do this, but nevertheless she still continued to take a considerable part. Much of this post-war development was, however, under conditions which made private financing somewhat precarious and the British Government gave substantial assistance through the Trade Facilities Act under which loans were guaranteed. In connection with this the Treasury made extensive use of consulting engineers both for vetting the projects and also for maintaining a general supervision of them during their execution. At that time (except for South America and China) the United States had not begun to take much interest in overseas investment and after unfortunate experiences in those countries, coupled with her lack of familiarity with overseas work, she tended to fall back on work at home for which her rapidly expanding economy gave full scope.

However, since the last war, the position has been very different. Britain has found difficulty in providing large capital sums for overseas development, even in the Commonwealth, while the United States has been in a position to provide vast amounts. In doing so she has been building up an increasing knowledge of the problems involved in her change from a debtor to a creditor country. Canada is in a somewhat similar position but on a relatively smaller scale, particularly since she has been engaged on extensive internal development which has made heavy calls on her capital resources. The general effect is that, so far, during the post-war period, it is North American capital which has been the main source of both technical assistance and loans through whichever channel they may have been provided. There seems, however, to be some prospect of increasing participation by Great Britain in future years. The Economic Survey for

1953 suggests that over a period of years it should be possible for the United Kingdom to develop an annual surplus of some £300 million to £350 million.

For various reasons the provision of private capital for overseas investment has been almost negligible, especially for public utility purposes. These reasons have been analysed by the United Nations in a recently published study and this does not encourage hopes of any early improvement. The consequence has been that such finance has had to be mainly provided by the more developed countries, and in particular the United States, through various government agencies.

The six principal organisations concerned with promoting projects in under-developed countries are :

(*a*) The Technical Assistance Board (T.A.B.) of the United Nations Organisation (U.N.O.) ;

(*b*) The Foreign Operations Administration (F.O.A.) of the United States ;

(*c*) The Colombo Plan ;

(*d*) The International Bank for Reconstruction and Development ;

(*e*) The Export-Import Bank of Washington, and

(*f*) The Colonial Development Corporation, to which has recently been added

(*g*) The Commonwealth Development Finance Company.

[The president then gave a brief survey of these organisations.]

Policy of Financial Agencies Towards Technical Assistance

Some of these agencies, and in particular T.A.B., seem to make a practice of providing individual experts rather than advice from consulting engineering firms. While this is probably the best—and often the only—way of dealing with many of the activities of U.N.O. such as food, health, labour, aviation, &c., it is not the most efficient way of studying large public utility projects. This tendency to employ individual experts, either with or without local assistance from the countries concerned, is also discernible in other agencies and fields and deserves some consideration as its relative inefficiency is not always apparent in non-engineering circles.

No individual can be thoroughly expert on all the details of a complex engineering scheme or have the breadth of knowledge and accumulated experience of those large firms of consulting engineers who are accustomed to major commitments abroad and to dealing with both the engineering and economic aspects of a project. Many of them have permanent organisations in Commonwealth countries and, in addition, have staff seconded to particular projects all over the world. The substantial support given by our power authorities at home ensures intimate contact with, and day-to-day experience of, corresponding work in this country, but, in addition, many firms make a practice of arranging constant visits of their partners and senior engineers to overseas countries in order to keep in touch with developments abroad and keep abreast of world knowledge. In particular, certain firms make a regular practice of sending experts to visit North America in order to keep fully conversant with American technique. Such periodic visits—usually with the object of studying some particular matter—may often make a larger contribution to knowledge than the more diffuse information and criticisms supplied by the widely publicised visiting productivity teams.

There is, however, another aspect to which the latest report of the Colombo Plan refers. That is the difficulty of recruiting sufficiently high-grade individual experts—or even *ad hoc* groups of such experts. This is because modern engineering is essentially team work and all the best men are part of some such team. In consequence, we find important projects involving vast expenditure often being studied and reported upon by those who are far from being in the first rank. Sometimes with great difficulty and under strong pressure based on the national importance of the arrangement, the first rank man may temporarily be released from his organisation, but, even so, must inevitably be less effective than he was in his normal position as part of a team. He may even be given authority to build up a new team, but an efficient team is not built overnight or even in a year—and depends on much more intangible factors than technical knowledge.

Apart from efficiency there is the question of cost. Experts who are asked to drop their normal work and take up temporary assignments inevitably run some risk through such interruption to their career and will only do so for exceptional remuneration or from a strong sense of public duty. Consulting engineers, on the other hand, exist and are organised for the specific purpose of providing such advice and any specific assignment can be undertaken in their stride.

It is perhaps largely the fault of consulting engineers themselves for not ensuring that their services are properly appreciated by the many political and financial organisations which have sprung into being since the war, but that, in turn, is largely due to the professional restrictions which have hitherto been placed on removing the misunderstandings and remedying the lack of knowledge. I trust that the opportunity which you have afforded me will do something to remedy this.

"All-in" Bids

I would briefly mention here a development which is of considerable concern to this country, and that is the practice which has developed in the United States, Asia and Europe of "turnkey" or "all-in" bids for complete projects. A "turnkey" bid, as this American expression implies, is an offer to design and complete a project lock, stock and barrel at a more or less lump sum price. Thus it is a comprehensive "all-in" offer covering consulting services, manufacture and construction.

It is widely felt in this country that such a system is not usually in the interests of the client and that the client-consultant-contractor relationship, based on the normal practice of obtaining competitive tenders with the assistance and guidance of a consulting engineer responsible for design, is likely to produce a cheaper and better job. However, the comprehensive offer is undoubtedly attractive to certain overseas clients who do not realise that the normal consulting fee is included, usually at a higher rate, in the comprehensive bid.

For this reason, and at the urgent request of the Board of Trade, very careful consideration is at present being given to arrangements whereby British consulting engineers can assist groups of British contractors to put forward comprehensive offers in competition with those obtainable from abroad. The general idea is that British consulting engineers would assist a group of contractors in the designs necessary for the preparation of a comprehensive tender and would subsequently carry out, on behalf of the group, the usual functions in connection with manufacture and erection. It should, however, always be possible for the client to appoint the consulting engineer direct after the comprehensive offer has been accepted and, in this manner, to revert to the more normal practice which, as already mentioned, is generally regarded as definitely preferable.

The Impact of Atomic Energy

In view of the great importance to all electrical engineers of recent progress towards the development of atomic energy for industrial purposes, and the wide and deep interest which it arouses in the public as a whole, it may seem surprising that I have not referred to it in this address, neither will you find reference to it in the valuable series of papers we are going to discuss. The explanation is that while we all appreciate that atomic energy may prove to be the most important single factor in the promotion of electrical development at home and overseas—the theme of this convention—the stage has not yet been reached at which it can be discussed in detail. It is recognised that the public information about atomic power has had to be limited for security reasons and we electrical engineers can at present add nothing to it. It is, however, sufficiently detailed to indicate that developments are taking place at a speed which has been unexpected and with gathering momentum.

It appears probable that in the quite near future not only will it be possible to produce energy from nuclear fuel in natural uranium reactors on a large scale at a price competitive with coal, but that reactors of the enriched and breeder types may be developed to a commercial stage sooner than was expected even a year ago. It therefore would seem that no restriction on our coal resources is likely to slow up electrical development and, indeed, that we may look forward to it being vastly increased because the only form in which, at present, it appears possible to apply atomic energy to industrial and domestic use is by its conversion to electricity through the medium of established forms of heat engine, using it as a substitute for the present orthodox fuels.

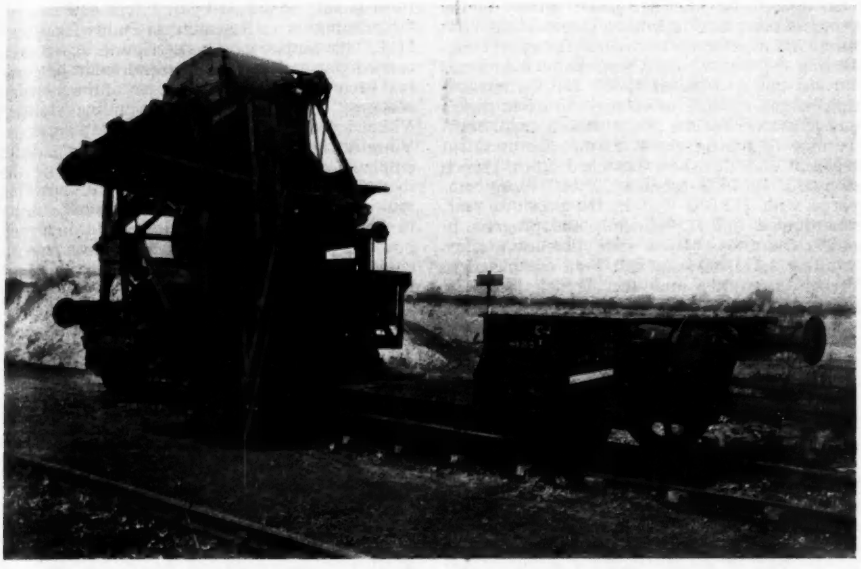
Our industry has been anxiously awaiting the opportunity to take some part in this development of atomic power which so greatly affects its future and we therefore welcome the establishment of the Atomic Energy Authority as a separate corporation responsible to the Lord President of the Council and charged with the duty of developing atomic energy for industrial—as distinct from military—purposes. One of its functions is "to distribute information relating to, and educate and train persons in, matters connected with atomic energy or radio-active substances," and I think all branches of our industry would wish to pay tribute to the way in which the new Corporation, under its able chairman, Sir Edwin Plowden, is interpreting that obligation.

My address has been largely devoted to the contribution which consulting engineers may make to British participation in electrical developments overseas, and to the essential need for this to be broadly based on work at home : I am sure I can speak for my fellow consulting engineers in expressing our appreciation both to the Atomic Energy Authority and to the British Electricity Authority for their recognition that this applies equally, and possibly with even greater force, to participation in the industrial development of atomic power in which many parts of the Commonwealth are taking much interest—particularly those which are rich in uranium.

I trust that my efforts to remove the bushel hiding the light of the consulting engineering profession have been made with discretion. Nevertheless, I hope they have let sufficient light shine to attract the notice of all those concerned with the study, development and finance of power projects—particularly those in under-developed countries.

Railway Ditching Machine

A RAILWAY ditcher, designed and built by Jack Olding and Co., Ltd., of Hatfield, Herts, for cutting trenches at the side of railway tracks, is shown in operation in the accompanying illustration. The machine is built on a rigid framework which is supported on a cradle pivoted on the deck of a railway wagon. Its digging boom is a modified arrangement of a Barber Green 5ft 6in machine, with twenty-two self-cleaning buckets. The buckets are 18in wide and they can be extended by fitting side cutters to 21in or 24in effective width. A trench can be cut up to a maximum depth of 6ft 3in below rail level by vertical adjustment of the boom.



Railway ditcher for cutting trenches up to 24in wide and 6ft 3in below rail level. The machine is shown with boom swung into operating position with cross conveyor extended

Suspended from the boom is an 18in cross belt conveyor which is driven by a reversing bevel box on the head shaft so that spoil can be discharged to the centre of the wagon or outside the trench. The conveyor is adjusted by a winch to discharge the spoil up to 6ft away from the trench.

The boom assembly, complete with the engine, gearboxes, traction winch and jack shaft, can be swung through 360 deg. to enable the ditcher to cut on either side of the wagon. The frame can be traversed through the main support cradle for a distance of 2ft by means of a hand-operated hydraulic jack, to enable the centre line of the trench to be varied between 3ft and 5ft from the near rail. When digging, the cradle is secured to the wagon floor and jacked up to relieve the load from its support rollers. In the travelling position the complete assembly is swung round to lie within the area at the bottom of the railway wagon, so that the complete machine is within the loading gauge.

The power unit for the ditcher is a six-cylinder Perkins "P6" diesel engine governed at 1400 r.p.m. and developing 48 h.p. Power is transmitted through a Ford four-speed and reverse gearbox and clutch, mounted on the engine and driving a 3·3 to 1 reduction gearbox through a flexible coupling. The jack shaft is coupled to the reduction gear output shaft and it carries a friction clutch and chain sprocket driving the boom hoisting winch and a dog clutch and sprocket driving the bucket line. For hauling the truck along the track during operation, a worm-driven winch is provided, holding 300ft of $\frac{5}{8}$in diameter wire rope mounted in the sliding frame. The winch is driven by an oil motor operated by a variable delivery vane pump mounted on the engine. The travel speed is variable, up to 6ft per minute.

The normal output of the ditcher cutting at its full depth of 6ft 3in below rail level is 0·61 cubic yard per minute when cutting a 24in wide trench at a speed of 1½ft per minute. Where conditions permit a speed of 2½ft per minute, the output rises to 1 cubic yard per minute.

The controls for the engine, clutch, gear change, boom hoist, winch speed, traversing, &c., are grouped on the frame in such a position that they can be operated from the cab mounted on the boom side of the cradle. The scraper hoist and conveyor winch controls are mounted on the boom and the winch dog clutch is mounted close to the drum. A further control for canting the sliding frame and the attached digging boom to correct for superelevation on curves is provided through worm wheels and screw jacks in the cradle, which raise or lower by 4in the inner support rollers of the sliding frame.

Whilst the buckets are in operation the trench is cleared by a close-fitting scraper behind the line which collects all loose material and returns it to the buckets. This scraper is hoisted clear during the initial cut by a chain winch and lowered into the trench as soon as sufficient clearance has been obtained. It is secured by a spring release which allows it to swing clear if it should foul an obstruction.

We are informed that this machine has already undergone preliminary tests under the auspices of engineers of British Railways, Western Region, and it was shown at the International Railway Congress exhibition at Willesden Motive Power Depot.

Hand-Operated Oil Switch

WE illustrate an oil switch (type "OS4/2") developed by The General Electric Company, Ltd., to comply with British Draft Standard CR (ELE) 2032, which defines an oil switch as "a device suitable for making a circuit in oil under normal and abnormal conditions such as those of short circuit, and capable of breaking a circuit in oil under normal conditions."

This switch can be supplied in extensible form with air-insulated, compound-insulated or oil-immersed busbars, or it can be incorporated in non-extensible ring main units, as in Fig. 1. In this example, the oil switches are mounted above the oil circuit breaker in the space normally occupied by the busbars of a standard oil circuit breaker unit. Provision is made for accommodating current transformers and essential metering. The switch is designed for service on 3·3kV, 6·6kV or 11kV systems and has a normal current carrying capacity up to and including 800A, with ratings of 150 to 250MVA at 11kV, 150MVA at 6·6kV, and 75MVA at 3·3kV.

The moving contacts are twin blades held apart by an intervening collar. They are spring loaded to make firm contact with the two sides of the solid copper fixed contacts in the "On" and "Earth" positions. When current is flowing the electromagnetic forces assist in keeping the fixed and moving contacts together, particularly under short-circuit conditions. The switches are hand-operated from the front of the unit, the operating mechanism being designed to give a quick make-and-break action. Access to the operating handle is provided by a hinged front cover, the position of the switch being indicated through openings in the cover. Neon voltage indicators and test plugs can be supplied if required.

Fig. 1—Non-extensible ring main unit with door open to expose the operating handle and interlocks

Each oil switch is interlocked through the medium of a slotted disc which must be rotated by hand, clockwise or anti-clockwise, until the position of the slot permits the desired movement, any other movement of the switch being positively prevented. The position of the interlock disc to permit operation between "Off" and "On" is shown in Fig. 2.

Interlocking of the test plugs is accomplished by a moving shutter, with holes that register

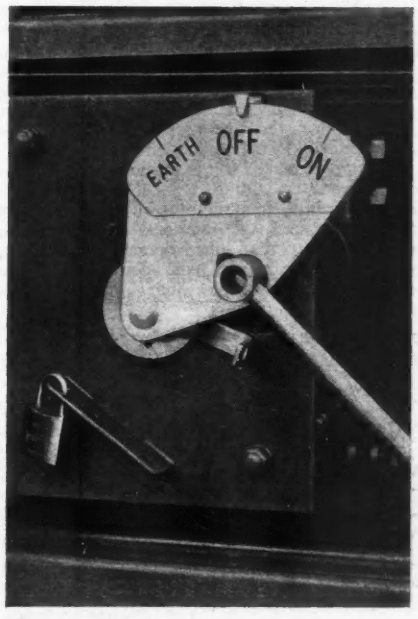


Fig. 2—Position of interlock disc to permit operation from "Off" to "On."

exactly with those in the fixed top plate of the unit only when the switch is in the "Earth" position; the plugs can then be inserted. Each moving shutter (Fig. 3) is actuated through a link mechanism designed so that the switch may be moved to "Off" when the test plugs are in use. This operation is accompanied by a slight movement of the shutter, sufficient to lock it against shoulders on the plugs so that they cannot be withdrawn until the switch is returned to the "Earth" position. A positive stop prevents the switch being closed in the "On" position while the test plugs are in use.

A bracket welded on the interlock disc in conjunction with a fixed strip on the switch panel

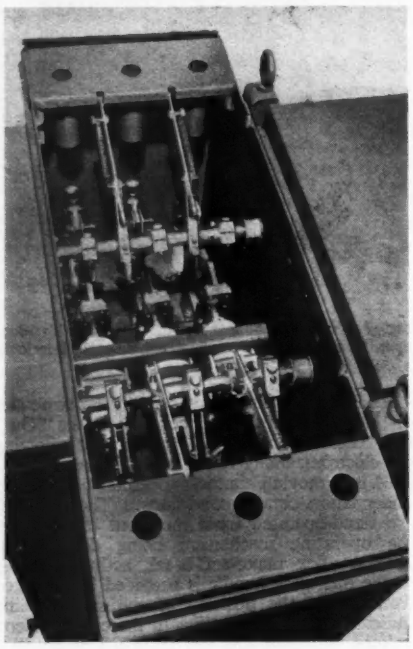


Fig. 3—Switch chamber showing link mechanism and shutters for isolating test plugs

enables a simple and positive system of locking to be used to prevent unauthorised operation. Depending upon the position of the padlock, the following safeguards are available :—Oil switch locked in the "On," "Off" or "Earth" position; interlock disc free to be moved into the required position for operating the switch between "Off" and "On," but locked from "Earth"; interlock disc free to be moved into the required position for operating the switch between "Off" and "Earth," but locked from "On." The second and third of these conditions can be combined so that each can be under the control of a different attendant who can thus only perform the operations for which he is responsible. Two padlocks are then necessary and they are placed in the top and middle holes of the fixed strip with the bracket on the interlock disc between them; removal of the appropriate padlock releases the interlock disc to permit either of the two specified operations. Finally, the cover over the test plug apertures and the hinged front door of the switch compartment can be locked.

Fabricated steel cable boxes are provided and ample space is allowed for cable jointing.

European Farm Radio and Television Association.—The creation of a European Farm Radio and Television Association was decided upon at the conference on the use of radio in farm advisory work and farmer's education which was held last month in Rome. The conference was organised by the Ministry of Agriculture and Forestry of Italy on behalf of the Organisation for European Economic Co-operation and under arrangement with the United States Foreign Operations Administration. It is stated that the objects of the new Association are to promote relationships between farm broadcasters in Europe, to improve farm radio and television, to encourage closer liaison between professional farm broadcasters and the technical advisory and information services of government departments of agriculture and other farming organisations, and to exchange programme ideas and material.

Association Technique Maritime et Aeronautique

THE fifty-third meeting of the Association Technique Maritime et Aéronautique opened on the afternoon of Monday, May 31st, at 2, Place de la Bourse, Paris, and was continued on the three following days, June 1st, 2nd and 3rd. Monsieur Max Bahon, the president, who opened the meeting, gave a survey of the progress made during 1953 in shipbuilding, both naval and merchant, and in aircraft construction. During the course of his remarks he mentioned various classes of naval vessels and the application of gas turbines associated with free piston gas generators for the propulsion of small craft. Turning to the merchant marine, the president recalled that the ships launched from French shipyards in 1953 totalled 235,000 tons, compared with 213,000 tons in the previous year, and quoted figures indicating the progress in other countries. Since the liberation ships totalling 1,371,000 tons had been completed in French shipyards and the French fleet, he observed, now amounted to 3,511,631 tons, while 644,000 tons were under construction in French yards and 127,000 tons in foreign yards for French owners.

Research and development were reviewed and brief mention made of certain items, including the behaviour of ships among waves, steering gears, launching stresses, launching, welding, aluminium alloys, corrosion and cathodic protection. The president also referred to ships' equipment and the use of new materials and then went on to call attention to trends in both steam turbines and diesel engines, and also the construction of gas turbines for an oil tanker and of atomic machinery for a submarine. He named the most important ships completed during the year and then mentioned that at present two designs for a new French Atlantic liner were being examined, one being for a ship of 52,500 tons having a length of 290m and a speed of 31 knots, the corresponding figures for the second design being 45,000 tons, 255m and 25·25 knots; both ships would have geared turbine machinery. With reference to aircraft, Monsieur Bahon mentioned the latest speeds attained and continued by discussing new aircraft and aero-engines and the developments in the United States, Great Britain and France.

Two papers were read on Monday afternoon, "Conceptions and Possibilities of S.E. 5000 'Barondeur,'" by J. Dor and "The Bathyscape of the French Navy," by A. Gempp and P. Willm. The first paper mentioned that the "take-off-chassis and landing skid" was adopted in developing a high performance plane capable of dispensing with a specialised ground organisation, and that tests had demonstrated the efficiency of the skid on many kinds of ground. It was stated that the adoption of the "Barondeur" by the navy would entail only minor modifications to aircraft carriers and that the arrangement is lighter than the standard landing gear and so would increase the payload of commercial planes. Later, a film was shown of the development of the "Barondeur." In the second paper the authors gave a historical account of the building of the "Bathyscape," and of the general principles of operation, together with a summary of the trials carried out.

The meeting was continued at 9 a.m. on the morning of Tuesday, June 1st, with a paper entitled "Marine Corrosion of Steel Structures," read by G. Dechaux and E. Segol. This paper gave the results of practical experiments carried out, since 1948, in the corrosion laboratory of Toulon dockyard on the behaviour of corrosion cells in an alkaline and aerated medium such as sea water. The effect of surface condition was established by means of separated and adjoining electrodes and in interpreting the results regard was paid to the oxidising power of the solution. The results, it was stated, have been embodied in cathodic protection in an aerated medium and the pigmentation of anti-corrosive paint. The next paper, "Contribution to the Research on the Protection of Ships' Waterline Plating," by L. Combret, recounted the complexity and difficulties of the research carried out by the Laboratoire de Chemie-Corrosion-Peinture of the Toulon yard, and stated that the results to date held out hope of improvement of present conditions. In the third paper, presented by J. Faure and entitled "Contribution to Research on Paints for Ships' Hull," the author gave a description of the tests carried out and said that considerable progress had been made. In the last paper of the morning session, "Vibration Systems, Including Multiple Viscous Damping: Application to Torsional Vibration in Shafting," the author, A. Girandeau, emphasised the importance of determining the dynamic balance of a complex system, including multiple sources of viscous damping and subject to several harmonic excitations, and indicated how the practical work of such an investigation could be reduced by applying electrical analogy methods.

Five papers were presented during the afternoon, and the first of these was "The Aircraft Carrier in 1954," by Admiral P. Barjot. This paper reviewed technical developments since 1952 and noted possible future improvements. The next paper was "Standardisation of Plates for Shipbuilding," in which the author, P. Hubert, gave an account of the application of standard plate sizes and the results of several years of experience of employing this system. In the third paper, entitled "Distribution of Alternating Current on Board Merchant Ships," the author, R. Courault, discussed the adoption of alternating current on board ship and the increasing size of electrical installations. He mentioned the progressive selectivity of protection devices and the principles of distribution, and explained his proposed simplified distribution system. L. Carpentier presented the next paper, "Voltage Regulation of Alternators on Board Ship," and stated that the adoption of alternating current on shipboard entailed the fitting of accurate and quick-acting voltage regulation devices by reason of the differences between the regulations for direct and alternating current. The essential functions of the voltage regulation systems were given and also a description of certain devices, together with the results obtained from recent installations. The fifth paper presented was "Short Circuit Currents in Ship Alternating Current Installations," by C. F. Maupas and R. Guerinet, and it examined the problem of protection from short circuits in alternating current installations on board ship. The authors summarised the differences between direct and alternating current in this respect and discussed how short circuits develop. The admissible short circuit impedances for the calculation of short circuit currents were dealt with and also the principles of a practical method for the determination of maximum peak short circuit currents.

On Wednesday morning, June 2nd, the meeting opened with the reading of "New Structure for Cargo Ships," by E. Baleine du Laurens and P. Legand, a paper which proposed modifications to present construction to allow a ship to carry a variety of cargoes with equal efficiency. A. Audige presented the next paper, "Recent Studies on Fire Protection: Fire Prevention in Shipbuilding," and observed that the London Convention for Safety of Life at Sea involved a revision of the Merchant Marine Decrees. This work called for special study of fire protection methods and the paper recounted the research carried out in France and outlined the resultant conclusions. "Possible Applications in France of Method I of the London Conference" was the title of a paper given by G. Sagne. The paper related the various limited tests of fireproof subdivision bulkheads on board ship and reviewed the materials used and the construction difficulties. The general consequences of the use of this form of subdivision were considered, especially with regard to weight and the author suggested how Method I could be

adopted without involving additional weight or greatly increased cost. This paper was followed by "Remarks on the Establishment of Refrigeration Balance in Ships," by E. Merlin, in which the author calculated the different balance items of an empty ship and gave the results of an experimental check upon the calculated figures. A quick and practical method for obtaining the balance of a laden vessel was given together with an estimate for a banana carrier, followed by notes upon the advantages of pre-refrigeration. The fifth paper of the morning was "Means of Protection from Moisture on Board Ship," by P. L. Bain and A. O'Connell. In Section "A" of the paper, the authors considered the protection of the ship's structure and cargo by ventilation and dehydration of air, and discussed the causes of moisture condensation, the rational ventilation of holds, and the necessity of moisture control and also the use of air dehydrating procedures. The second part of the paper was concerned with the protection of the structure in oil tankers by the use of dry air.

The first paper read on Wednesday afternoon was "Some Remarks upon Transverse Stability, Especially that of Light Escort Vessels," by H. Amiot, and the author, after repeating elementary stability considerations, stated that a comparison between modern escort ships and light pre-war naval craft showed that weights had increased, and that this increase could not be compensated solely by adding to the beam. Professor H. E. Jaeger presented the second paper, entitled "Determination of Sizes of Vertically Corrugated Transverse Bulkheads," in which he developed a method for calculating the sizes of this design of bulkhead. The calculations for the corrugated plates took into consideration the resistance to buckling of the flat parts and the author indicated the possible saving in weight by using this form of bulkhead. The next paper was "Contribution to the Experimental Research on the Strength of Bulkhead Stiffeners Under Fluid Pressure," by H. Dutilleul. This paper described tests to establish the loading on bulkhead stiffeners subjected to fluid pressure in order to compare these stresses with the theoretical bending stresses of a girder of constant section, having standard end connections, submitted to a uniform transverse pressure. The last paper presented during the afternoon was "Sea Trials of the Passenger-Cargo Liner 'Jean Laborde,'" by R. Brard, M. Jourdain and D. de Mas Latrie. This paper, which is a continuation of that given in the previous year with reference to the trials of the "Ferdinand de Lesseps," gave the results for the "Jean Laborde," a sister ship, which was submitted to more extensive trials, but at a different displacement. The trials were analysed upon the basis of a diagrammatic method, which has proved effective in allowing a comparison to be made between the two ships as well as between the "Jean Laborde" and its model, which was run in the experimental tank under comparable conditions.

The meeting was continued on the morning of Thursday, June 3rd, when M. Salmon-Legagneur read his paper "How Far May Steam be Conveyed Economically?" in which he related the distance over which steam can be delivered economically to: the cost and efficiency of centralised boiler rooms compared with individual central heating; the cost of piping; the fuel costs as affected by wholesale and retail prices, and to the cost of lagging the piping. It was shown that the distance is affected by the conditions under which the steam is produced and the uses to which it is put before being piped away. In the next paper, "Operating Results Obtained with Two Velox Boilers," presented by J. Morelle, the author restated the particulars of the Velox boiler installations on board the liners "Camboge" and "Ville de Tunis." He gave information on the performance of these boilers in service and added details with regard to the fouling of the tubing systems and feed units. The third paper of the morning session was read by G. Cahen and entitled "Some Properties of Selected Non-Linear Servo-Mechanisms." Research methods on the stability of servo-mechanisms were reviewed briefly by the author and the properties of linear systems given, together with a definition of selected non-linear systems. Mention was made in the paper of the Loeb stability criterion and a demonstration given of the Nyquist criterion, while the author suggested a method for carrying out research work on non-linear servo-mechanisms. The next paper was "Note on Plane Transonic Flows: Generalisation of the Mach Number," by R. Marchal and P. Servanty. This paper consisted of three sections and the first part gave a detailed study of air flow in a vaneless plane diffuser of a centrifugal supercharger which has revealed certain new aspects, including the characteristics of the number which controls the possibility of the appearance of shock waves. The second part of the paper was an extension to the plane flows established in the first part, the method adopted being that of tangent flow derived from the theory of finite increments. It was stated that of the nine new propositions formulated, the fifth appeared to be the most important. An outline application of this method, to transonic flows brought into being around the section or at the air intake of engines, including jet engines, formed the third part of the paper.

The meeting was continued on Thursday afternoon, with the reading of five papers, the first of which was "Sagging Stresses and Cargo Loading," by R. Crenn, in which the author outlined a simple method of determining, for a vessel in service, whether the distribution of a given cargo would give rise to undue sagging stresses. A typical calculation was included in the paper for a cargo ship of about 7000 tons. The object of the next paper, "Photo-Elastic Investigation of Stresses Around Drainage Holes in Keelsons," by M. Ballet and Miss C. Salmon-Legagneur, was to define by means of a stress concentration coefficient the weakening effect of drainage holes. Tests were made by the photo-elastic procedure on "T" shaped models hydraulically loaded, and the results of the experiments indicated that oblong openings offset from the plate edge probably gave rise to lower stresses than circular openings directly abutting the bottom plating. The next paper, by H. de Leiris, was entitled "Experimental Study of Fatigue Tensile Strength of Welded Connections for Oil Tanker Bottom and Deck Stiffening Plates." This paper stated that the opposing requirements of strength and simplicity of construction called for a compromise which cannot be arrived at, from a structural point of view, without concise knowledge of the resistance to cyclic stresses. The test pieces dealt with in the work consisted of the welded connections of the deck and bottom longitudinals of oil tankers. Owing to the complexity of the structure a limited number of models were used and the results of the first tests were discussed. In the fourth paper, "Research on Stresses in Bolt Head Fillets Under Tension," the author, J. Auband, described the experiments carried out on five bolt heads by the photo-elastic method, also the plane and three-dimensional tests carried out by the strain recording method and discussed the results obtained. The final paper of the afternoon session and the last of the meeting, was presented by A. Augustin-Normand, Junior, and entitled "Shop Testing of Marine Propelling Machinery Consisting of Free Piston Generators and Gas Turbines." This paper described the arrangements for testing the free piston generators and gas turbine machinery for minesweepers and coasters, and recorded the results of the shop trials, which, it was stated, were confirmed during sea trials.

Annual Dinner

The annual banquet of the Association Technique Maritime et Aéronautique was held on Thursday, June 3rd, at the Hotel Lutetia, Paris, and was attended by French naval officers, naval architects, marine engineers and officials representing the departments responsible for the French Navy, Merchant Marine and Air Force, together with the Naval Attachés of a number of countries and representatives of the British technical press. The principal guest, Monsieur Gavini, Secretaire d'Etat aux Forces Armées (Marine), was introduced by the president, Monsieur Bahon, and in reply Monsieur Gavini said that the role of the engineer was to keep closely in contact with research and its practical application. He also emphasised the need for close co-operation between the Merchant Navy, the Navy and the Air Force, since the two navies were interdependent and the merchant fleet, which was essential for the transport of supplies, needed, in time of war, the protection of the fighting Services. The Minister went on to give some details of French naval construction requirements and mentioned the building of a new aircraft carrier of 22,000 tons at Brest.

The Association Technique Maritime et Aéronautique and the Chambre Syndicale de Constructeurs de Navires et de Machines Marines had arranged for the British technical journalists to pay two visits during their short stay in Paris, and first of these was to the works of the Compagnie de Construction Mécanique Procédés Sulzer at Saint Denis, on the bank of the River Seine. The company was founded in 1918, at the instance of the French Government, and since then has been engaged in building diesel engines for marine purposes and for railway traction, centrifugal pumps and refrigerating machinery, the annual capacity of diesel engines and pumps being about 125,000 h.p. and 180,000 h.p. respectively. A tour was made of the works to see something of the work in progress, and it was noted that the siting of the machines was in keeping with an economic use of floor space. At present the largest Sulzer marine diesel built has cylinders of 720mm diameter and a stroke of 1250mm, but the company expect to build the latest Sulzer design of engine of 760mm cylinder diameter by 1550mm stroke.

On the following day (Friday) the group, by permission of the Service Technique des Constructions et Armes Navales, was able to pay an interesting and instructive visit to Le Bassin d'Essais des Carencs de Paris. Directeur des Constructions Navales, Ferdinand Reech, who was contemporary with William Froude, and also discovered the law of comparison between model and ship, was the founder of the Paris Tank. In use at present is a towing tank measuring 160m in length by 10m wide, and 4m depth, and it was of interest to note that preliminary tests of models of the proposed new French Atlantic liner were under way. However, a new tank is under construction and this has a breadth of 13m, a depth of 4m and a length of 181m, which it is planned to increase to 220m and later to 320m. The new tank is to be fitted with a wave generator possibly of the pneumatic pattern. A small tank serves for yacht and barge testing, while another tank, which has a length of 55m by 8m wide and 0·8m deep and is, at a later date, to have the length and depth increased to 155m and 2m respectively, is at present arranged to represent a length of the Suez Canal for the purpose of testing shallow water effect on resistance.

The new tank, mentioned above, is connected with the steering basin, which has a diameter of 65m and a depth of 5m. In the basin, which is completely covered, steering trials are carried out either using radio-controlled, self-propelled models, or with models fixed to a rotating arm. A camera on a centre island records the movements of the models, and records are made of the torque on the rudder, propeller revolutions and angular movement. A cavitation tunnel equipped with automatic recording instruments is available for testing propellers up to 40cm diameter. In another building are other small tanks in which rolling and stability trials are carried out and studies made of the pitching behaviour of ships in ahead and astern seas.

Petroleum Equipment.—The Council of British Manufacturers of Petroleum Equipment has published a "Classified List of Equipment and Services," which lists the officers and executive committee, the members of the various advisory committees, and the members. There is a classified list of equipment and services arranged in alphabetical order and an extensive index.

Aluminium Mill Brochure.—We have received from T.I. Aluminium, Ltd., a brochure entitled "Aluminium Mill Finish Sheet," which deals with the matt "mill finish" produced in the company's new mill near Resolven in South Wales. The production flow and main processing units are illustrated and briefly described, and the succeeding sections of the brochure are devoted to the general application of the material to building, automobile engineering, agricultural and dairy equipment, commercial transport, packaging, domestic equipment, and electrical engineering. Each section includes drawings illustrating possible applications.

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RAILWAY MODERNISATION

The well-organised meeting of the International Railway Congress Association in London, with the exhibition at Willesden, and the various special displays arranged for Congress delegates, made up a colourful picture of some of the highlights of British Railways. It gave the kind of impression that one gains on attending certain large railway functions abroad, when the administrations concerned are naturally displaying their best. In London this year it was a very fine display indeed, but the distinguished visitors who were delegates to the Congress, shrewd and experienced railwaymen themselves, would not necessarily judge British Railways by the luxury of the accommodation provided and the smoothness of the working on the Congress specials, any more than we ourselves should base our judgment of the railways as a whole on "The Golden Arrow" or "The Elizabethan." Nevertheless, while studying the exhibits at Willesden one could not help feeling how much pleasanter it would be for ordinary travellers if modernisation could be put in hand on a really comprehensive scale, and what a tonic it would be for railwaymen in general to have a general issue, so to speak, of new and modern equipment. For many years now British Railways have been forced to the policy of "carrying on" and "making do," and it is not surprising that the traditional sense of pride in the job is wearing a little thin in places. Sir Brian Robertson's promise of a big programme of modernisation is therefore to be welcomed on all hands; but we hope that the large capital expenditure eventually to be authorised will be spread so as to give the greatest possible all-round improvement, rather than spectacular improvements in a few concentrated areas, leaving the *status quo* elsewhere.

The protagonists of full-scale main-line electrification are inclined to regard their policy as the panacea for all railway ills, and it was recently asked outright whether we can much longer afford not to electrify. A vast amount of money might be spent on such a scheme, but unless the system of traffic regulation along the busiest lines was very thoroughly overhauled also, the results, so far as punctuality of operation, might well be disappointing. To-day, in the suburban area of the Southern Region boat expresses and other important long-distance trains have to be given relatively slow point-to-point times in order to fit in with the intense electric local service. What is now necessary on the Southern might be necessary on other lines, due to freight traffic and the frequency of shunting and light engine movements across main lines at large intermediate traffic centres. One of the most interesting points brought out in the Congress discussions on signalling was the way in which the German Federal Railways are using the system of coded remote control known as C.T.C. for signal operation on busy double-tracked main lines. The co-ordination of working between a string of manually operated boxes needs to be very close for delays to be avoided, and for all traffic, passenger and goods alike, to be kept running at the scheduled speeds; and the centralising of control—providing a traffic regulator with the whole picture over a wide area, by means of an illuminated diagram and control panel—has had spectacular results, even on the limited scale on which it has so far been applied in this country.

The cult of the traditional is, however, deeply ingrained in British Railways, and just as there are some who cling to the idea of having at least two signalboxes for a large station, against the modern conception of a single centralised control, so there are many who necessarily associate dirt and a general atmosphere of gloomy depression with steam traction. A high proportion of our present stud of steam locomotives is of modern design, and basically well able to cope with the traffic. The latest of them include features designed to counteract the worsening conditions at many of the running sheds. But on reflection this seems to us suspiciously like condoning a fundamental weakness, that should not cost a great deal to eradicate. The Norfolk and Western Railroad, in the U.S.A., provides an outstanding example of how a limited and careful expenditure on steam locomotive servicing facilities can improve the all-round performance, and there is no doubt whatever that the associated tidying-up, smartening-up, and cleaning-up acts inevitably as a tonic to every man on the strength, from top-link drivers to the humblest shed hand. By far the most serious criticism to be levelled against British Railways to-day is that of unpunctuality, yet even with the uncertainties arising from present-day coal a very low proportion of that unpunctuality can be attributed to motive power. It is in the regulation of the traffic that the weakness lies, and there, clearly, lies the greatest field for thorough modernisation. Some routes would amply justify full electrification, and it is interesting to learn that the main line from Euston is to be examined with a view to electrification at 50 cycles per second; but it is equally clear that with fully modernised servicing equipment a large number of relatively new, existing steam locomotives could be rendered capable of considerably enhanced performance. When the modernisation plan of the British Transport Commission is put in hand we hope it will prove to be a judicious blend covering many facets of the working, so as to spread the improvement as widely as possible over the railway network of the country.

GRAPHITE IN CAST IRON

Ever since the application of the phase rule to the iron-carbon system over fifty years ago, the co-existence of graphite and carbide in the same cast iron has been a matter demanding explanation. The original suggestion, that a solid solution graphite eutectic separated, followed at a lower temperature by a reaction between the solid solution and the graphite resulting in the formation of carbide, instantly met with objection as being contrary to practical experience with the malleablising process. Some years later, Goerens concluded from his study of the subject that the iron-carbon system should be considered as one of iron and iron carbide and that the rate of cooling, both before and after freezing, was the factor which mainly determined the ratio of free to combined carbon in a cast iron. Two schools of thought developed. One group of investigators held that an austenite-graphite eutectic was formed directly from the melt. The other group maintained that the austenite-cementite eutectic (ledeburite) was always formed first, and that the formation of graphite was a secondary process. The work of Hatfield and of others associated with the industry demonstrated to the satisfaction of many people in this country that the formation of carbide (or silico-carbide) was necessary before free carbon could be obtained. Publications giving support to one or other of the alternative views have been voluminous, and investigators are still debating the question, as was shown at the Iron and Steel Institute meeting on May 27th, when this and some other outstanding matters of dispute were discussed.

It appears that the present position is

something of a compromise. It is generally conceded that coarse flake graphite and graphite with a rosette formation form directly from the liquid, but on the origin of fine graphite, the so-called undercooled graphite, there was no agreement. Swedish investigators, who were well represented at the meeting, opposed the interpretation placed on the work of Eash in America and of Morrogh and his associates at the British Cast Iron Research Association, which was considered to establish beyond doubt the origin of fine graphite from the austenite-cementite eutectic. Further evidence was provided by the B.C.I.R.A. investigators indicating that fine graphite in cast iron arises from the decomposition of a carbide. The origin of this form of graphite was also investigated by Berman and Kondic at Birmingham University. They compared the time required for the formation of graphite on cooling with that required for cementite to decompose at and below the eutectic temperature. The close similarity of the times compared in this way showed that fine graphite could be formed by the decomposition of cementite during the eutectic arrest or immediately after complete solidification. On the other hand, Professor Hultgren and his co-workers came to the conclusion from their own experiments that the appearance of graphite-austenite aggregates, their composition, and their general manner of development judged by the structure of quenched specimens in relation to the cooling curves, indicated direct formation from the melt by eutectic reaction. Thus, the question of the origin of fine or undercooled graphite was still left unresolved. Dr. Allen set the exponents of the idea that cementite forms first and graphite second the very difficult experimental task of clearly demonstrating, in the same part of the same specimen, a sequence of structures, on continuous cooling, from the liquid, through the cementite eutectic (ledeburite), to the condition where graphite appears. Meanwhile those who held that all undercooled graphite formed directly from the liquid were asked by Mr. Morrogh to explain the day-to-day practical experience of a foundry which produced rainwater pipes. For this purpose the cast iron mould, 15ft long, is in two parts, the top half being hinged along one edge. Molten metal is poured in, the mould is closed and the excess metal is squeezed out. If the casting, which is approximately $\frac{3}{16}$in thick, is left to cool in the mould, it comes out white. The casting, therefore, solidifies white, but if it is stripped from the mould shortly after it has solidified it is grey, with fine graphite of the undercooled-graphite type. Here was a piece of evidence which, unlike laboratory tests, was repeated on thousands of occasions.

During the fifty years in which discussions on this topic have been going on, the guaranteed minimum tensile strength to which cast iron could be made has risen from about 15 tons to over 35 tons per square inch. An important stage in the progressive advance was the discovery of nodular or spheroidal graphite cast iron. The origin of this form of graphite was also discussed at the meeting. It was stated by Mr. Morrogh that cooling curves and quenching experiments indicated that graphite nodules may form directly from the liquid, though they may also be formed by decomposition of carbide. Austenite dendrites were first formed in the liquid. Then, just before or at the time of final solidification of the eutectic, graphite nodules appeared in the eutectic interstices of the dendrites. Subsequent solidification proceeded by the growth of these nodules and the development of austenitic envelopes. It was suggested by other speakers that the adoption of a spherulitic rather than a flake form was connected in some way with decrease in the rate of growth of the graphite, possibly owing to the action of some impurity. In a paper from the Swedish Institute for Metal Research, Stockholm, it was shown by autoradiography of a nickel-carbon alloy that the rare earth elements which induced nodular growth were uniformly distributed through the spherulites. It is, however, evident that much further work remains to be done on all these problems. The difficulties of experiment and of interpretation are considerable. The iron-cementite diagram refers to metastable conditions. The temperature interval separating the metastable from the stable (iron-graphite) eutectic is small. Experimental work with pure synthetic alloys presents special difficulties, which are increased when results are applied to commercial cast irons which contain many impurities, and owing to the presence of these the eutectic does not freeze at constant temperature. The iron-carbon, silicon diagram is usually a more appropriate standard of reference for grey cast iron. Thus, in spite of the increased accuracy of pyrometric measurements and improvements in metallographic technique, no completely acceptable answer to the question, " How and when is the graphite formed ? " is yet forthcoming.

Obituary

H. P. SMITH

We record with regret the death of Mr. H. P. Smith, manager of the experimental department of Rolls-Royce, Ltd., Derby, which occurred on June 3rd. Mr. Smith had completed forty-three years' service with Rolls-Royce, Ltd., which he joined as an office-boy in 1911. In the following year he became an apprentice fitter, working in the chassis test department. During the first world war, Mr. Smith was employed in the engine test department on " Falcon " and " Eagle " engines, the first aero-engines to be made by Rolls-Royce, Ltd. At the end of the first world war, Mr. Smith transferred to the experimental department, being promoted to the position of manager in 1936. During the second world war, Mr. Smith was responsible for the manufacture of all the Rolls-Royce prototype aero-engines as well as the " Meteor " tank engine. In addition, he had charge of the firm's experimental establishment at Barnoldswick, Lancashire.

TOM MAKEMSON

We regret to have to record the death of Mr. Tom Makemson, which occurred suddenly at Stretford, Lancashire, on Thursday of last week, June 10th. Mr. Makemson, who was sixty-four, had been secretary of the Institute of British Foundrymen for the past twenty-eight years. Prior to that, he was for some years honorary secretary of the Institute's Lancashire branch. Soon after his appointment to the secretaryship of the Institute of British Foundrymen in 1926, Mr. Makemson became secretary also of the Manchester Association of Engineers, which appointment he held until 1948. This year, the Institute of British Foundrymen is celebrating the fiftieth anniversary of its foundation. Its development and activity during the first fifty years—to which Mr. Makemson has made a notable contribution—are recorded in a jubilee booklet, entitled *The First Half Century*, which he wrote a few months ago.

Gas Industry's Programme

Progress made by the gas industry of this country in recent years and its programme of development in the immediate future are outlined in a booklet, " Fuel for the Nation : The Gas Industry's Programme," just published by the Gas Council. As stated in the recent White Paper, the programme is on lines generally approved by the Minister of Fuel and Power. Part of the expenditure required for the capital equipment needed by the industry to carry out its plans will be financed from provisions made for depreciation, but the balance will need to be financed from external borrowings. During the four years from vesting date to March 31, 1953, the financial requirements of the industry amounted to £212 million, £37,000,000 of which was met internally. The £212 million represented : expenditure on capital assets, £155 million ; liquidation of vesting day overdrafts, £27,000,000, and working capital, &c., £30,000,000. The present development plan covers the ensuing seven years, during which it is expected that capital expenditure will amount to some £366 million (including £20,000,000 working capital). Of this amount the industry itself will finance some £92,000,000, leaving the balance of £274 million to be raised externally. The present borrowing powers of the Gas Council and the twelve Area Gas Boards are limited by the Gas Act, 1948, to £250 million. The time is approaching when this limit will be reached, and the Gas Council is therefore applying for the limit to be raised by £200 million to £450 million.

The demand for gas, which rose by 8 per cent during the three years to March 31, 1953, is expected to increase further as a result of new housing developments and the continually growing use for industrial processes. By 1959–60 total gas consumption is estimated as 2924 million therms compared with 2524 million in 1952–53. To meet these demands, it is estimated that manufacturing capacity must be increased from the 1953 total of 11,189,000 therms a day to 12,795,000 therms. The additional capacity will be provided partly by an increase in carbonisation plant from 7,564,000 therms to 8,078,000 a day, and partly by an increase in water gas and other plant from 3,625,000 therms to 4,727,000. These increases will not meet the whole of the additional demand for gas ; it is expected that the amount of gas purchased, mainly from coke ovens, will increase from 342 million therms to 483 million therms during the period.

The integration and interlinking of undertakings has been one of the industry's major tasks in recent years, and it is hoped that by 1960 the plans of the Area Gas Boards for such integration will have been almost completed, with a consequent cessation of gas-making at the smaller, less economic works and a concentration of production in the larger, more efficient units.

The amount of coal needed for gas-making by 1960 is expected to be 29,200,000 tons, an increase of only 6 per cent over the present figure, although the total gas available is expected to increase by 15 per cent. This is due, on the one hand, to the increased quantities of coke oven gas which will be purchased, and also to the use of water gas plant, which uses coke instead of coal, to provide much of the necessary additional gas-making capacity.

Consumption of oil by the industry is expected

to increase from 437,000 tons a year to 577,000 tons. Because of the amount of water gas plant to be brought into operation, the production of coke for sale will rise by only 682,000 tons of the estimated increase in production of 1,047,000 tons. The production of other products, however, should rise proportionately with the increase in coal carbonised.

In order that these plans may be implemented, it will be necessary to lay a further 14,654 miles of main.

British Electricity Conference

THE British Electricity Conference met in Eastbourne on Monday last. A summary of the address given by Lord Citrine, chairman of the British Electricity Authority, is reproduced below.

The progress made in the industry since the vesting date was maintained during the year ended March 31, 1954. Over half a million consumers were added, bringing the total up to nearly 14½ million—2¾ million more than at the vesting date. The consumption of electricity increased by 6·9 per cent over the previous year. Despite increased capital and operating costs, it is estimated that the overall revenue per unit rose by a comparatively small amount.

The shortage of steel which occurred two years ago adversely affected the commissioning of new generating plant, which amounted to 1413MW s.o. as compared with 1539MW s.o: in 1952. It is anticipated that the upward trend will be resumed in 1955, and will rise to 1950MW s.o. in 1959 ; 6206MW s.o. of plant has been put in service since the vesting date, representing roughly 8½ million horsepower. Turbo-alternators, each with a capacity of 200MW, operating on the unit principle with boilers of 1400k.lb per hour capacity and having steam conditions of 2350 lb per square inch and initial temperature of 1050 deg. Fah. with reheat to 1000 deg. Fah., are planned for commissioning in the 1959 programme. These sets are to be installed in the power station to be built at High Marnham on the River Trent, some 10 miles from Newark.

Overall thermal efficiency of generation was 23·22 per cent for the calendar year 1953, as against 20·87 per cent at the vesting date. Availability of generating plant maintained the progressive improvement of recent years and, to expedite repairs, the Central Authority has decided to establish a limited number of its own central workshops. Plans for the first two of these are being worked out.

There was only one power cut during the winter, and twenty-one instances of voltage and frequency reduction, compared with six power cuts and eighty-six instances of voltage and frequency reduction in the winter 1952–53. On February 2, 1954, the plant carried the record load of 15,430MW. This compared with 9501MW during the winter preceding the vesting date.

Because of the possibility of a coal shortage, the Central Authority is considering the use of dual firing for coal or oil at the Marchwood (Hampshire) station and is examining the position in respect of sixteen other stations situated on the estuaries of rivers. Close co-operation has been established, between the Central Authority and the Atomic Energy Authority, and members of our engineering and technical staff will be trained in the design, construction and operation of nuclear power reactors for the generation of electricity. The 15,000kW gas turbine at Trafford Park is undergoing running trials, and the 100kW wind power plant is nearing completion.

Rural development has been speeded up, and 12,941 farms were connected last year, or about three times as many as before the war ; 60,000 additional farms will be connected by 1958, and a further 45,000 by 1963.

Area Boards have made further progress towards the simplification and standardisation of tariffs, and attention has been given to special terms for off-peak loads with a view to improving the load factor. Eight Boards have published standard off-peak or restricted-hour tariffs. The bulk supply tariff has been fixed for 1954–55 at £4 15s. per kilowatt of simultaneous maximum demand and 0·5d. per unit running charge, subject to a regional fuel clause adjustment of 0·00065d. per unit for every 1d. variation from 60s. per ton of coal.

District heating and similar projects are under consideration at Bloom Street (Manchester), Spondon, Stepney and Warrington. The economics of the Pimlico scheme are being closely investigated. District heating schemes usually involve heavy capital expenditure, but the Central Authority is willing to examine any scheme, the economic aspects of which show a reasonable prospect of being financially sound.

The financial results for the year 1953–54 are not yet available, but the surplus will probably be substantially larger than in previous years. Parliament has under consideration a Bill to increase the borrowing powers of the Central Authority from £700 million to £1400 million.

The Authority has amalgamated, as an experiment, the Merseyside and North Wales Division and the North-Western Division to obtain experience in the working of a unit larger than the existing Divisions.

A Bill has been introduced into the House of Commons with the object of establishing a new South of Scotland Electricity Board, with similar local rights and responsibilities to those of the North of Scotland Hydro-Electric Board. The proposed vesting date is April 1, 1955. The Government feels that the title " British Electricity Authority " will no longer be appropriate, and a new title, " Central Electricity Authority," is proposed.

Literature

The Great Iron Ship. By JAMES DUGAN. London : Hamish Hamilton, Ltd., 90, Great Russell Street, W.C.1. Price 16s.

THE name of I. K. Brunel is recognised by most engineers as that of perhaps the most versatile of men in the profession, while it was yet in its infancy. He was known as the builder of railways, bridges, docks and tunnels, but probably the achievement which attracted most attention was his steamship, " Great Eastern," launched in 1858, a ship five times as big as any other then existing, and one not exceeded in size until the advent of the celebrated Cunarders, " Lusitania " and " Mauretania," in 1906. Driven by a combination of paddle wheels of 58ft diameter and a single screw 24ft diameter, dimensions not yet exceeded, she also carried 6500 yards of sail and with her six masts and five funnels she presented a unique appearance.

If the reader is looking for further technical information than has already been published elsewhere he will be disappointed in this book, but if he would have a complete and very readable detailed history of the famous ship he will be fully satisfied. After a brief description of the ship itself has been given the author faithfully describes the difficulties experienced in its broadside launch, as well as the spectacular crossings of the Atlantic, a service to which she was put in spite of Brunel's preference for trading to the Far East. The way she stood up to a freak storm proved her solid structure, but financial difficulties were repeatedly encountered, accentuated by the striking of an uncharted rock. This led to heavy expenditure, indeed everything tended to prove that, wonder ship though she was, she was in advance of her day, being too big for current requirements. But we read that success came when she was diverted to cable laying, and the story of how she laid the first transatlantic cable, and the troubles and disappointments encountered, proves interesting reading ; however, this work could not continue indefinitely and in 1874, with the advent of the cable ship " Faraday," the " Great Eastern " became virtually obsolete. The grand old ship now entered upon her decline, and was made a show boat taken from port to port, changing owners, but ever leading to more money being lost, until in 1890 she was converted into scrap ; but even at this point she was a source of anxiety, for never before had so large a breaking down job been undertaken. Sir Daniel Gooch chronicled : " I would much rather the ship was broken up than turned to base uses. Poor old ship, you deserved a better fate," a sentiment shared by most engineers.

For the first time the whole life story of a remarkable ship is available, and the engineer can spend a very pleasant few hours of relaxation in reading this book, which is well illustrated, and in so doing his estimation of such men as Brunel and Gooch will be much enhanced.

The Determination of Crystal Structures : Vol. III, The Crystalline State. By H. LIPSON and W. COCHRAN. London : G. Bell and Sons, Ltd., York House, Portugal Street, W.C.2. Price 50s.

THE appearance of Volume III of *The Crystalline State* will be welcomed by all physicists and chemists who are interested in the determination of atomic parameters in the unit cell. It will, no doubt, become a standard reference book on structure analysis.

The art of crystal structure determination is now forty years old, and this book reveals the rapid progress that has been made since the early geometrical analyses of the Braggs. The authors have summarised in a masterly fashion all the main technical methods of analysis, with well-chosen examples for illustrations. Trial and error methods, the use of graphical and mechanical devices, are all fully described, and one feels the necessity of being an expert in this work to make full use of the information presented. To the expert this book will surely become just " Lipson and Cochran."

This is hardly a book which can be recommended to engineers. There are many practical uses to which X-ray diffraction methods can be put in the non-destructive testing of materials. The determination of strain, residual stress, grain-size and orientation, and the identification of impurities are just a few of the problems which can be tackled. The engineer must wait for the publication of a parallel book on these topics before he can regard X-ray diffraction as a necessary technique in his work.

BOOKS RECEIVED

Strength and Elasticity of Materials, Vol. III. By W. H. Brooks. London : Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 25s.

Clock Cleaning and Repairing. Edited by B. E. Jones. London : Cassell and Co., Ltd., 37/38, St. Andrew's Hill, Queen Victoria Street, E.C.4. Price 4s. 6d.

Clarke's Tables and Memoranda. Tenth edition. Revised by P. Honey and W. J. Woolgar. London : B. T. Batsford, Ltd., 4, Fitzhardinge Street, W.1. Price 8s. 6d.

The Steel Skeleton. Vol. I: *Elastic Behaviour and Design.* By J. F. Baker. London : Cambridge University Press, Bentley House, 200, Euston Road, N.W.1. Price 42s.

Diesel and High-Compression Gas Engines—Fundamentals. By E. J. Kates. London : The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.3. Price 44s.

The Microscopy of Metals. Lectures delivered at the Institution of Metallurgists refereshser course 1953. London : Institution of Metallurgists, 28, Victoria Street, S.W.1. Price 15s. 6d.

The Spectrum of Steel. A table for the selection of homologous spectral lines. By J. Convey and J. K. Hurwitz. Canada : Department of Mines and Technical Surveys, Mines Branch, Ottawa. Price 1 dollar.

Iron and Steel Institute

ANNUAL GENERAL MEETING

No. III—(*Concluded from page* 849, *June* 11*th*)

ON Thursday morning, May 27th, there was a joint discussion on the following papers :—

"Eutectic Solidification in Grey, White and Mottled Hypo-Eutectic Cast Irons," by A. Hultgren, Y. Lindblom and E. Rudberg ; "Structural Changes During Annealing of White Cast Irons of High Sulphur-Manganese Ratios," by A. Hultgren and G. Ostberg ; "The Growth of Nodular Graphite," by M. Hillert and Y. Lindblom ; "The Solidification of Nodular Iron," by H. Morrogh ; "Undercooled Graphite in Cast Irons and Related Alloys," by H. Morrogh and W. J. Williams ; "Solidification in Iron-Phosphorus-Carbon Alloys," by H. Morrogh and P. H. Tutsch ; "Decomposition of Cementite During Solidification of Cast Iron," by A. Berman and V. Kondic.

A long technical discussion followed from which we draw upon the remarks of only two speakers.

Discussion

Dr. R. V. Riley (Staveley Iron and Chemical Company) : These papers are, I think, most important in that they will be regarded for some time to come as an indication of the present state of our knowledge of the metallurgy of cast iron. You will see that they are dominated by the name of Mr. Morrogh, who, with his keen intellectual brain, has brought some measure of simplicity from a mass of experimental results from a large number of sources. The fundamental conception of the metallurgy of cast iron has for many years been undergoing a change. In the early days of Professor Turner the simple iron-carbon diagram appeared capable of representing cast iron alloy with a sufficient degree of accuracy. Now, thanks to the recent developments which have taken place in the malleable field and with nodular graphite irons, this simple concept does not appear to be adequate. The mode of formation of graphite has, of course, received most attention and with it the equally important subject of carbide formation and breakdown. The work at the British Cast Iron Research Association has demonstrated, I would think, beyond reasonable shadow of doubt the existence of a silico-carbide in addition to cementite, thus confirming the original ideas of W. H. Hadfield and, much later, many other workers, including myself. The vexed problem of where the graphite in the iron comes from—whether from the liquid or the solid—has apparently in the papers been solved by a compromise. It comes from both. The British workers, however, appear to indicate that graphite in hypo-eutectic iron can come directly from both the silico-carbide and from cementite, and this, I think, is quite an important conclusion which apparently, however, is not completely acceptable to our Swedish friends. The form of the iron-carbon diagram still appears to be a major unknown quantity, and from the point of view of knowing what the iron-carbon diagram can bring to further the metallurgy of cast iron I think we must hope for some further excellent work from sources in Sweden and from the British Cast Iron Research Association.

Mr. T. Henry Turner (British Railways Metallurgy Research Directorate) : The history of cast iron started apparently with people trying to find out what was put into it, and now we are at the stage of looking at what we have got, and as you look at these metallographic examinations I am afraid you may feel that cast iron is getting so complicated it is getting beyond the ordinary user's understanding as to what he is using, but despite the complication of the subject there is no doubt that great progress is being made. I think it must have been thirty years ago when I first met Professor Hultgren, and if we just think over that period, at that time—1924—we surprised the Director of the Cast Iron Research Association by producing a cast iron of 16 tons, and now they are talking of specifications of 35 tons as regular, usable material for an engineer, so that in that period we have jumped from 16 up to 35 as a material which we hardly know whether to call cast iron or cast steel. It is something new, and so far as we are concerned in this country a new chapter was opened by Morrogh ; he made us understand what was in cast iron in a way we had never seen before.

On Thursday afternoon there was a joint discussion on the following papers :—

"New Swedish Mill Designs and Layouts for Medium and Small Sections and Wire Rod," by E. Norlindh ; "The New Fagersta Wire Rod Mill," by K.-E. Pihlblad ; "Roller Bearings in Swedish Rolling Mills and the S.K.F. Rolling Mill Design," by A. Leufven ; "Practical Experience in the Use of Repeaters in a Looping Mill," by H. W. Riddervold.

The second and third papers were presented jointly by Mr. A. Leufven.

Discussion

Mr. T. W. Hood (Samuel Fox and Co., Ltd.) : The subject dealt with in these papers is of interest in this country to those people who are the fairly small producers and, in particular, to those people who produce special steels, the nature of the product meaning that the tonnages involved for each size and quality are very small. We are talking about the medium output from flexible mills. The types of mills which can be used for this purpose can be grouped in three classes. The first—and we have heard these described this afternoon—are those using repeating throughout in the intermediate and finishing trains. The second are those which repeat the sections and, as the stands are grouped in pairs, treat the ovals as individual two-stand continuous trains joined by repeaters. Thirdly, there are those with looping intermediate trains and tandem continuous finishing trains. The big question in the minds of most of us is, which of those three, and in particlar which of the two—the continuous finishing train or the looping finishing train—will be satisfactory and most reliable for our purpose. I am open-minded on the matter. I have not had to make up my mind, which is perhaps just as well. In America we know of one mill working very well with the continuous finishing train and in Sweden at S.K.F. Hofors there is a rod mill with continuous finishing train and with no pulling between stands because of looping troughs. They presumably give an accurate product, and as far as I know the method was no more expensive because the stands were all of light and reasonably inexpensive design.

Roller guides have figured in the paper to a large extent. I want to back up Mr. Norlindh, because, as he knows very well, we have tried such a guide, home-made and to a slightly different design but essentially the same, in our rod mill at the last pass where there was difficulty because the minimum speed had to be increased. That works extremely well.

The next comment concerns temperature variations in the billet being ironed out in wire rod due to the high rolling speed and little cooling time between passes. Temperature efficiency is important when rolling precision bars. What tolerances are achieved by these stands ? Are they better than those rolled by some older mills which still exist in Sweden ? May I ask Mr. Riddervold a question on the time to change, not stands but passes, because he goes to great lengths to say how he has put the question of guides and setting on to a scientific basis as opposed to the art, as it largely is, in this country. Does that involve trouble in changing over from one pass to the next, particularly from one size to another, without any change of rolls or stands ?

Mr. R. Stewartson (Guest, Keen and Nettlefolds, South Wales, Ltd.) : For those who are used to a continuous rod mill, the first thing which will strike them about the layout given by Mr. Norlindh is the long path which the bar has to travel in coming from the roughing stand to the final rod stand. The path is about 1000ft. That compares with 300ft to 400ft in a modern high-speed rod mill. I want to ask whether that long path results in a low finishing temperature. In a continuous rod mill we should expect to drop something like 200 deg. Cent. between the furnace and the last stand. That would be reduced further in the pipes by water cooling before coiling. In particular, attention is drawn to the last six passes where the rod is thin and liable to lose temperature fairly rapidly. The path is 330ft to 340ft, compared with 50ft in a six-stand continuous finishing train. A feature about a long path on a mill which is on fairly continuous production—and it must be in these layouts—is that if there are a number of bars in the mill at one time, a cobble in the finishing train means that you are likely to lose two or three bars in the mill—those which are being rolled at various stages. Is that so ? What is the loss of yield due to cobbles ?

Turning to the repeaters, the remarks which the authors made about whip are very much to the point, but we have found that with a repeater between the two stands, each with individual electrical drive and a fine speed control available, it is possible to loop up to 2000ft a minute and keep the bar more or less within the channel, thus controlling the whip when the bar leaves the preceding stand. In other words, a fine speed control helps a lot in controlling whip. That is something which cannot be done when two stands are driven from one motor, as described in the papers.

Mr. W. Craig (Davy and United Engineering Company, Ltd.) : I was very interested in Mr. Norlindh's remarks about the application of the machine with universal spindles. We have treated that as gospel for a long time and it is interesting to hear from another source the value of applying a machined universal spindle. Mr. Norlindh has succeeded in producing a design which is more or less self-lubricating. I have always been of the opinion that the application of good lubrication considerably lengthens the life of all the universal elements. It is apparent that the trend of design in Sweden is to produce a unit which will have a wide diversity of products and at the same time require only a minimum of manpower. We are told that manpower is exceedingly scarce in Sweden and that that which they have probably does not want to do too much. In that respect we find that the Swedish

engineers have proved themselves to be most ingenious. They have gone a long way in the quest for 100 per cent automatic operation. That seems to me to be the trend of design throughout all these stands which have been described in the papers. This mechanical mindedness fills me to a certain extent with apprehension. Mr. Norlindh calmly says that the continuous billet casting process will probably render the cutting mills obsolete in a few years' time. Mr. Leufven put on the screen to-day a picture comparing the old, conventional housing with the prestressed housing—probably with about one-quarter the weight. I wonder what we engineers will be doing in a few years' time ? I was interested in the papers on the application of roller bearings, which were obviously treated with the importance which they deserve. In that respect, I was particularly interested in the method of mounting these bearings. From a comparison of the figures it is clear that great importance is attached to the oil injection mounting process.

Mr. N. D. Thompson (United Steel Companies, Ltd.) : Mr. Norlindh has described various interesting and revolutionary features to our industry—a new stand design, high-speed repeaters with no twist guides, excellent roller entry guides, prestressed stands with setting devices so that we know what the spring will be when the piece is being rolled, very versatile layouts, and so on. This stand design is particularly interesting to people who have to replace existing units with new units. One of the main advantages is the very small space occupied. Mr. Riddervold said that in his mill he used to have six stands across the bay, but that he now has twelve. What a boon that would be in some of the Sheffield rolling mills ! We have seen an excellent design of roller entry guides, and Mr. Hood has tried it with excellent results, but we have other types with two or three pairs of rollers and most engineers who advocate the use of roller guides have to make a recommendation. Would it be fair to say that Mr. Norlindh's design where the rolls themselves are very small and the bearings themselves are very small, is used best for small products ? I was glad to hear Mr. Riddervold say that yield had gone up recently and that on small products it was 93 per cent. In a continuous rod mill in this country we should expect 96 per cent yield. That difference of 3 per cent in yield, even on a mill rolling 100,000 tons a year, represents about 3000 tons. Those 3000 tons of products which have borne the full cost of production—assuming that the difference is cobbles—represents about £75,000 a year, if we are talking about mild steel. Does not that influence one's decision considerably as to whether one chooses a continuous train or a train with repeaters ? Having said that, we must think of these Swedish mill designs in terms of the Sheffield trade's type of mill, where we are rolling small quantities, various sizes and high quality. Here these layouts give that versatility and also high speed which gives us the big coil and the minimum temperature variation, because some steels have to be rolled through a very limited temperature range, and the roller guides in connection with quality of surface.

Mr. M. Langew (Loewy Engineering Company, Ltd.) : Very big roll diameters are used in Swedish mills producing comparatively small sections. For instance, the medium section mill reduces 40mm. Has that any great influence on the pass design ? I further notice that when two stands are driven from one motor in order to avoid too big a loop you increase the second stand considerably—by 2in, or even more. I do not think you can use a normal stand ; you would have to have a special stand to keep the top spindle more or less straight for these comparatively high speeds. It has been pointed out that there is a long distance between the medium mill and the small section mill to deliver the bar, but there is even a longer distance from the last finishing stand to the coilers. Can the coilers pull out of the tube when the rod has left the last stand or do you need pinchells for this work ? If they are used, have they any marking effect ?

The authors replied briefly and the meeting ended.

Colonial Civil Engineering Conference

THE Institution of Civil Engineers is this week holding its biennial summer conference on civil engineering problems in the Colonies. Members attending the conference are, during the course of the week, participating in various social events and visits to works and places of engineering interest around London. The last of the four technical sessions of the conference is taking place this morning. A brief account of the papers presented at the conference is given herewith.

Road Construction

On Tuesday, June 15th, two papers on Colonial road works were discussed, namely, " The Cross River Bridge, Nigeria : Construction and Organisation Problems," by Mr. K. E. Hyatt ; and " The Design and Construction of the Humming Bird Highway," by Mr. E. R. Rowbotham.

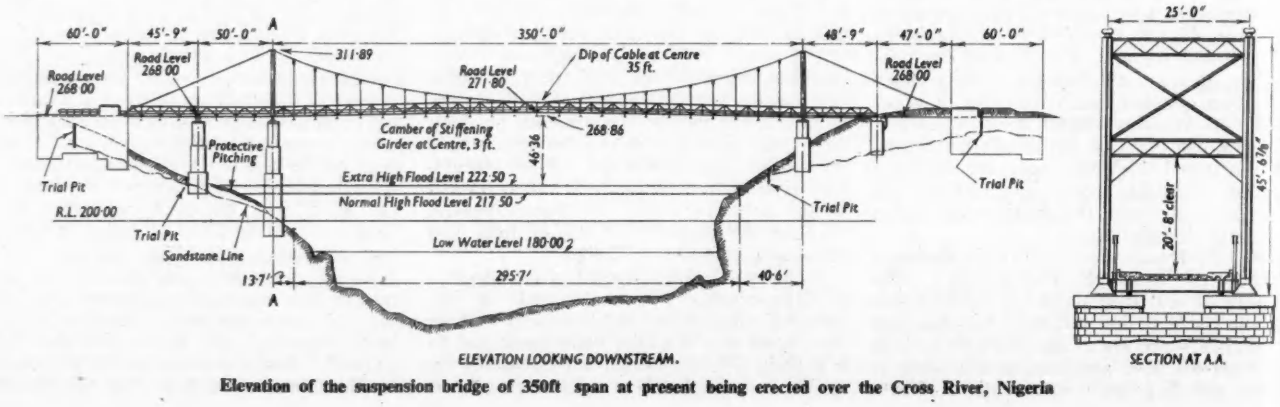
Construction of the Cross River bridge in Nigeria is only just commencing. The bridge will replace a ferry, and is considered to be an imperative necessity, because of the difficulty of communication on both sides of the Cross River, and of the development of the British Cameroons. The bridge is illustrated in the accompanying drawing, which is reproduced from Mr. Hyatt's paper, as are the following details of its construction.

A single-span bridge was clearly the most economical type, the paper states, and, although only of a comparatively short span, a suspension bridge offered great advantages in both erection and in giving a construction not necessitating large and heavy members. This was particularly important in view of the difficulties of local transport. The design adopted, therefore, was for a suspension bridge with a 350ft main span, straight back stays, and short independent approach spans. There is one 43ft 9in span on the right bank and on the left bank two spans, one 45ft 9in, the other 50ft long. On the left bank the anchorage is incorporated in the abutment, but this was not possible on the other side, where an independent pier supports the shore end of the approach span.

Each of the main cables is composed of seven fully locked coil wire ropes, approximately 1¼in diameter with a breaking strength of 170 tons. There are two cables down each side of the bridge supporting single hangers by split cable clamps and bridge pieces. The clamps are of mild steel with welded stiffeners, and the hangers are round mild steel rods, with turnbuckle adjusters, supporting compound cross girders by steel plate links. Warren trusses, 7ft 6in deep, are used as stiffening girders in bays of 16ft 3in, which is also the spacing of the hangers. The deck of the bridge is formed by steel troughing spanning between cross girders and filled with concrete.

Each main tower is composed of two steel legs united by lattice bracings ; each leg is formed of two web plates and eight angles, forming a double H section united by batten plates. The planes of the web plates lie directly under the axes of the main ropes and the supporting webs of the double cast steel saddle on each leg. These towers are 46ft 9¾in high including bearings and saddles. The tower bearings are of cast steel, each incorporating a pin to permit inclination of the tower in a plane parallel to the bridge centre line. The main girders of the approach spans follow the same general design as the stiffening trusses and are of the same height ; the cross girders are underslung and have the same deck construction as the main span.

The anchorages are to be of mass concrete with stepped footings and a chamber with a reinforced concrete roof is formed in each to house the ends of the cables. The bunched-up ropes of these cables splay out from a clamp to give room for their sockets ; each is anchored by a pair of short bolts to heavy steel crossheads These in turn are anchored to steel grillages embedded in the main mass of the concrete. Steel templets are provided to ensure correct alignment of the anchorage structures. Precautions are taken to exclude water from the



Elevation of the suspension bridge of 350ft span at present being erected over the Cross River, Nigeria

anchorage chambers and the main cables will issue from it by steel sleeves filled with bitumen. The piers are designed with mass concrete footings and the shafts are to be formed with precast concrete facing blocks with concrete hearting. All foundations are to be carried to sandstone rock.

The chief difficulty faced by the contractor is the necessity of reconciling two conflicting conditions imposed by the climate of Nigeria. At present road communication between the coast and the site make it impracticable to move any large amount of material by lorry, but transport is relatively simple by river. This, however, is during flood periods only. On the other hand, with a rainfall at the rate of about 200in per year the wet season is not the time during which it would be expected that work on the site could best be carried forward. Local transport on mud roads also becomes very difficult indeed at this time.

The port for Cross River is Calabar and the nearest railhead, at Enugu, is served either from Port Harcourt or Lagos. From Enugu to the site is a distance of about 130 miles over the road with two ferry crossings of rivers with maximum loadings of 5 tons. The bridges replacing these ferries and the road to Ikom from Calabar are under construction, but are not expected to be completed until about the same time as the Cross River bridge. The nearest administrative centre at Provincial level, with banking and full medical services, is Enugu.

The paper goes on to give an outline of the proposed constructional programme, and of some of the local difficulties in organisation and obtaining supplies of materials. Details of the site layout are given, and it is pointed out that the key item of plant is a 6-ton blondin cableway erected over the bridge centre line and serving the whole job. The work is being carried out for the Department of Public Works, Nigeria, for whom the Crown Agents for the Colonies are acting in London. Messrs. Coode and Partners are the consulting engineers and designers of the bridge, and the contractors are Dorman, Long and Co., Ltd.

Passing now to the second of the papers on road works, the Humming Bird Highway, which is so called because it passes through the Humming Bird Gap, is a road nearing completion in British Honduras. The author commences with a thumbnail sketch of the Colony and goes on to a more detailed description of the terrain through which the road passes. A short history of the project since its inception is given, with details of the designs for bridges and methods of construction ; finished prices for most of the operations are quoted. The road has a total length of 32½ miles, with a base course and semi-grouted metalled surface with a final seal coat. A hundred and forty culverts of various kinds were constructed as part of the works, as well as two major bridges over 250ft in length, three other major bridges and eight smaller ones.

Some Small Hydro-Electric Schemes

The second technical session of the conference, held on the morning of Wednesday, June 16th, included two papers : "The Hydro-Electric Developments in Territories Administered by the Colonial Office," by Mr. C. H. Pickworth and Mr. E. B. Cocks ; and "The Main Drainage of Dar-es-Salaam, Tanganyika Territory," by Mr. H. H. Dixon.

Some of the smaller hydro-electric installations, generally not exceeding 5000kW in capacity, in various Colonial territories, are described in the first of these papers, which also gives information about the supply systems of the various electricity undertakings which operate these schemes, and about the economics of some of these developments. The importance of long-term measurements of stream flow at potential hydro-electric sites is emphasised.

Main Drainage in Dar-es-Salaam

Main drainage works exceeding £400,000 in value have recently been constructed to serve Dar-es-Salaam, the capital of Tanganyika Territory. A comprehensive description of these works is given by Mr. Dixon in his paper. Provision has been made in these new works for future additions to the scheme, which are contemplated by the town planning proposals.

For the present scheme, asbestos-cement pipes were used for the sewers. Experience in breakages in transit, making joints, and figures showing carrying capacity compared with salt-glazed-ware pipes are given in the paper.

An automatically controlled electrically operated pumping station and screening works situated at the head of a 39in diameter sea outfall are described. Novel machinery has been developed to extract rags that occur in large quantities in the sewage of East African towns. Stones, detritus and rags are removed for disposal on land by special vehicles. Screened sewage is discharged by gravity to sea at all states of the tide, but sludge is pumped out to sea through a separate 8in diameter main only when the currents are suitable. The sea outfall is over 1000 yards long and consists of asbestos-cement Class A pressure pipes 1m internal diameter, supported by reinforced concrete piles in pairs. Adequate legislation and stringent drainage rules are indispensable, it is stated in the paper, and their enforcement is imperative if any scheme of sewerage is to be kept reasonably free from trouble.

The Dar-es-Salaam main drainage scheme was designed by the consulting engineers, Howard Humphreys and Sons, the principal contractor being M. Gonella and Co., Ltd.

Plant Maintenance

In many of the papers presented at the various Colonial conferences, emphasis has been laid on the difficulties of operating plant in remote places—of ensuring supplies of spare parts, and similar problems. On Thursday morning two papers on this subject were discussed : "The Maintenance of Civil Engineering Plant of the Public Works Department, Federation of Malaya," by Mr. A. B. Watson ; and "The Maintenance of Civil Engineering Plant of the Public Works Department in Northern Rhodesia," by Lieut.-Colonel S. F. Gauron. In the first of these papers reference is made to the necessity for increased use of mechanical engineers, standardisation, special equipment for plant maintenance, overhaul procedure, field maintenance and service, stores and records, and time and motion study as applied to plant operation. The procedures discussed are based on post-war experience in the maintenance of over £2,000,000 worth of heavy equipment.

Lieut.-Colonel Gauron's paper points out that it is important that a sound system of servicing and running adjustments is introduced, and that regular periods be set aside for servicing, and preventive action taken early when faults develop. Sufficient records must be maintained, a sound inspectorate branch formed, and an adequate supply of spares and a good stores control system provided, to keep the machines in action. The paper discusses the ways in which these objects have been achieved in Northern Rhodesia by the Public Works Department.

Freetown Harbour

This morning, the conference will discuss one paper only, entitled "Design and Construction of Harbour Improvements, Freetown," by Mr. D. C. Coode. The deep-water quay at Freetown, Sierra Leone, which has recently been completed, together with various other harbour improvements, such as the provision of transit sheds, warehouses, slipways, wharfside cranes, and diesel tugs, are described in some detail in this paper. These harbour works were built to the designs of Messrs. Coode and Partners, the consulting engineers, by the contractors, Pauling and Co., Ltd.

Multiple-Unit Electric Rolling Stock

ON June 14th the new electric service between Manchester (London Road) and Glossop was inaugurated. This service of the London Midland Region of British Railways is operated by eight three-coach, multiple-unit sets ; each set consists of a 1500V, d.c. motor coach, trailer, and driving trailer, and may be operated singly or coupled to another to form a six-coach train. All the electrical equipment for the new rolling stock was supplied by The General Electric Company, Ltd. The motor and trailer coaches were built by the Metropolitan-Cammell Carriage and Wagon Company, Ltd., and the driving trailers by the Birmingham Railway Carriage and Wagon Company, Ltd. The principal dimensions and passenger capacities are tabulated below :—

	Motor coach	Trailer coach	Driving Trailer
Length over body ...	60ft 4¼in	55ft 0¼in	55ft 4¼in
Width over side panels ...	9ft 3in	9ft 3in	9ft 3in
Height to top of roof ...	12ft 4¼in	12ft 4¼in	12ft 4¼in
Height to top of pantograph	15ft 1in	—	—
Bogie centres	41ft 3in	38ft	38ft
Bogie wheelbase	8ft 6in	8ft	8ft
Weight equipped but unladen	50·6 tons	26·4 tons	27·5 tons
No. of passengers (1st class)	—	24	—
No. of passengers (3rd class)	52	38	60

The three types of coach are of all-steel construction and are carried on swing bolster bogies. The bodies are arranged as open saloons with transverse and longitudinal seats ; on each side of each coach there are two 4ft 6in sliding doors with ample adjacent floor space for standing passengers. The doors are equipped for electro-pneumatic control from the guard's position, with permissive passenger operation as an alternative.

Heavy gradients between Manchester and Hadfield, combined with the need to operate over a wide voltage range because of freight working on the main line with locomotives equipped for regenerative braking, impose service conditions which may be regarded as severe in comparison with those of many suburban lines. The equipment is designed to function satisfactorily up to 1800V ; the average voltage is 1400V and the minimum voltage 1000V, but the equipment will operate satisfactorily on a voltage as low as 750V.

Each motor coach is powered by four axle-hung traction motors, arranged in two groups, consisting of two motors permanently connected in series, so that the motors individually do not operate above half line voltage. The groups are under series-parallel control with bridge transition. Acceleration is automatic and is set normally for 1·24 m.p.h. per second. Balancing speeds of a train unit, empty, on the level are approximately 58 m.p.h. in full parallel and 67 m.p.h. in parallel weak field. The safe maximum speed is 70 m.p.h.

The electro-pneumatic contactor control equipment is mounted below floor level on one side of the underframe in three cases with removable covers at front and rear for easy accessibility. The main resistances and battery are mounted on the other side of the underframe. A motor generator set with an output of 6kW at 52V is suspended from the underframe by resilient mountings.

To ensure smooth acceleration, there are ten resistance steps in series and four in parallel. Three continuous running notches can be selected by the master controller—full series, full parallel and full parallel weak field. If the motorman selects automatic acceleration up to weak field, an excessive current peak is avoided when passing from full parallel to full parallel weak field, by using a second accelerating relay having a lower setting. Besides the continuous running notches mentioned above, there is a notch for use when shunting and coupling up before automatic acceleration begins.

Overload and fault protection is given by line switches in conjunction with relays and resistance, one line switch being arranged to insert resistance in the fault circuit before the current is broken by the opening of two more switches in series. By this means the maximum possible breaking capacity is available at the train, and the sub-station or feeder breakers should rarely, if ever, be called upon to clear a vehicle fault.

The reverser is an electro-pneumatic drum switch. A hand-operated drum switch enables either pair of motors to be cut out in emer-

gency. Under these conditions a train consisting of one or more units may be operated for a limited period to clear the line and avoid delay. Contacts associated with the cut-out switches modify the control circuits so that the train as a whole is prevented from operating in series, although series combination remains operative for acceleration of the sound train units. Should a serious control fault develop, the control circuits may be isolated by a multi-point cut-out switch which permits the remainder of the train to be driven from the master controller and associated controls at either end of the faulty unit.

No-volt protection is afforded by a no-current relay. This relay is set by a l.t. shunt coil controlled by interlocks on the h.t. indicator relay. The coil is cut out on all except the "off" and first steps, and the relay is retained by a series coil carrying motor current. Any failure of line voltage will at once operate the relay and power will be cut off. On restoration of the line voltage the equipment will notch up automatically if the motorman has not switched off.

The four-pole series-wound traction motors are arranged for self-ventilation from intake louvres mounted high up on the sides of the coach. The sleeve suspension bearings are oil lubricated, and the armatures, carried in grease lubricated roller bearings, can be removed from the motor frames without opening up the bearing assemblies so that there is no fear of dirt entering the housings during this operation. The motor ratings at 700V, based on B.S. 173/1941, are as follows :

Continuous full field	133 h.p., 153A, 985 r.p.m.
Continuous weak field	157 h.p., 185A, 1290 r.p.m.
1 hour full field	185 h.p., 217A, 815 r.p.m.
1 hour weak field	210 h.p., 245A, 1055 r.p.m.

The h.t. motor and l.t. generator of the motor generator are combined in a single machine having two roller bearings only. This set is totally enclosed, with an external fan at the l.t. end which blows air along the outside of the ribbed frame. The motor is a two-pole, compound-wound machine with a shunt field fed from the 52V supply ; the generator is a four-pole machine without interpoles. A carbon pile regulator controls the l.t. voltage. The battery consists of thirty-three "Nife" cells, type "ES12," of 125Ah capacity at the 5 hour rating.

To prevent failure of either the battery or m.g. set from affecting the running of the train, all master control circuits and a section of the lighting circuit are fed from the battery side of the paralleling contactor for the battery and l.t. generator. To avoid undue demand on the battery in an emergency, the remaining lighting circuits are energised direct from the l.t. generator. In addition, essential power and brake control circuits may be energised from another train unit supply in the event of an abnormal emergency.

The passenger compartments of the motor, trailer and driving trailer coaches are provided with twenty-two 26W and twenty-four 60W lamps, respectively. Passenger lights throughout any train make-up are under the control of the guard. A changeover switch and plug enable most of the lights to be fed from a shed supply during cleaning and maintenance.

A 1500V feed is taken to the train heaters and is divided into two circuits ; one circuit feeds two circuits of seven heaters in both the motor-coach and driving trailer, and three circuits in the trailer ; while the other supplies one circuit in the motor coach and one in the driving trailer. There are twenty-one 400W heaters in each vehicle, arranged in three circuits of seven in series. The contactor controlling the feed to the greater number of heater circuits is governed by a thermostat, in addition to guard's push-button operation, so that the heating of passenger compartments is virtually thermostatically controlled.

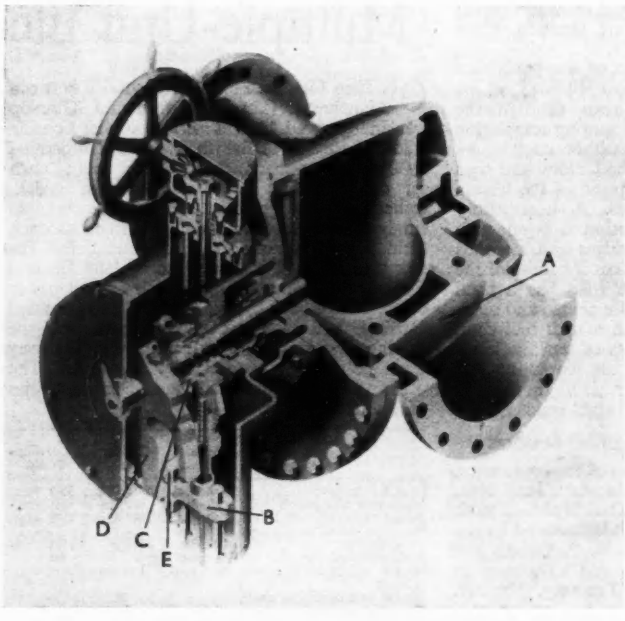
Westinghouse air brakes, with electro-pneumatic control, are fitted. The compressor is driven by a 1500V series motor fed through a protective resistance which is also common to the motor of the m.g. set. Both machines have individual fuses, and a special high-duty fuse functions as the main protection for the whole of the 1500V auxiliary circuits.

The single-pan lightweight pantrograph is designed so that the pan can follow small line irregularities without moving the main frame. It is raised by admitting air to a central cylinder so that the over-ruling down spring is compressed and the up springs are free to operate. Ball bearings are used extensively in the joints and all are shunted by copper braids. Lubrication is by grease nipples and the pan is designed to carry any of the special lubricating greases or paints. Two transverse torque bars carrying the lever arrangement whereby the pan is sprung to the apex of the pantograph frame ensure that the pan always remains parallel to the mounting plane, which has the effect of obtaining better clearance in tunnels.

Rotary Plug Valves

We are informed by the Harland Engineering Company, Ltd., of Alloa, that it is now making a range of "Rotovalves" in standard sizes up to 72in diameter under licence from the S. Morgan Smith Company, of the United States. These valves are essentially similar in design to plug cocks with an operating mechanism. As can be seen from one of the illustrations on this page, the bore of the body is slightly tapered to receive a conical plug. The operating mechanism actuates the plug axially for seating and unseating, so that when it revolves the plug through 90 deg. for opening and closing there is no contact between body and plug. As a result no face-to-face frictional resistance has to be overcome, and a self-cleaning action automatically takes place between body and plug.

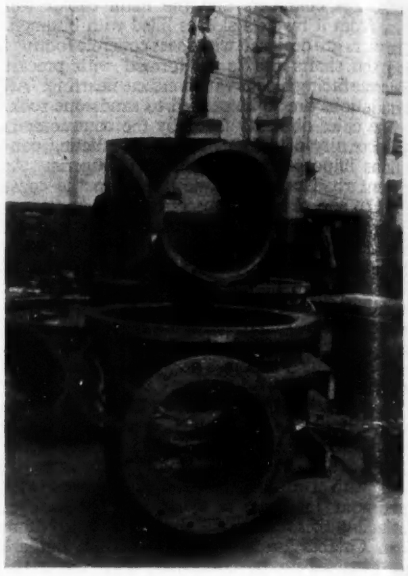
Monel metal seats on both body and plug are in contact when the valve is fully open and fully closed. Both the body and the plug have circular ports so that when aligned in the open position there is smooth, unobstructed flow from flange to flange. The top of the body is closed by a head cover, through which the plug shaft extends to the operating mechanism. This mechanism is protected by a fabricated steel housing, which also carries the driving device.



Mechanism of a hand-operated "Rotovalve" in which the plug is moved axially for seating and unseating so that it can be rotated freely without contact with the seating

As the valve seats do not come in contact with the direct flow of the fluid when the valve is fully open, pitting, erosion or wire drawing do not occur except during the very short periods of opening and closing.

Three bearings align the body, plug and operating mechanism in all positions. This, coupled with the fact that bearing pressures are kept low and that the valve seats are clear during rotation of the plug, ensure that valves can be opened and closed easily and quickly against full unbalanced pressure. There is no need for fitting a by-pass valve or other pressure equalising device across the valve.



Conical Plug being lowered into tapered bore in the body of the valve. The Monel metal seats in the plug can be clearly seen

These valves can be operated by hand or by electric motors, hydraulic or pneumatic power, and the mechanism can be seen in the illustration we reproduce, giving a section through a hand-operated valve. In this case the plug *A* is shown in the closed position. The crosshead *B* of the mechanism is connected to the handwheel through bevel gearing and a screwed stem, and is constrained to move in a straight line by two fixed guide rods. A lift nut *C* engaging threads on the plug shaft is connected to the crosshead by a lever and a link. Keyed on the end of the plug shaft is a "rotator" lever *D*, which is actuated by a roller *E* attached to the crosshead.

When the handwheel is rotated to open the valve the crosshead is first raised and through its lever it rotates the lift nut on the plug stem. As it can at that stage only move axially, the plug is drawn back and unseated. Further movement of the crosshead engages the roller with the rotator lever, and the lift nut and the rotator lever operate in conjunction to turn the plug to the open position. Towards the end of the crosshead movement the lift nut lever ceases to move as its connecting link passes over a dead centre position. With the lift nut stationary the rotator lever continues to turn and the plug shaft moves down the thread of the lift nut until the plug is reseated in the fully open position. When the valve is being closed the movements are reversed.

The makers point out that this design of valve has important anti-water hammer characteristics, as during closing 80 per cent of the port area is cut off in 40 per cent of the crosshead stroke, and thereafter the rate of closure decelerates although the crosshead is moving at uniform speed. The valves are adaptable for isolating, non-return, pressure and flow regulating, level control, and other duties.

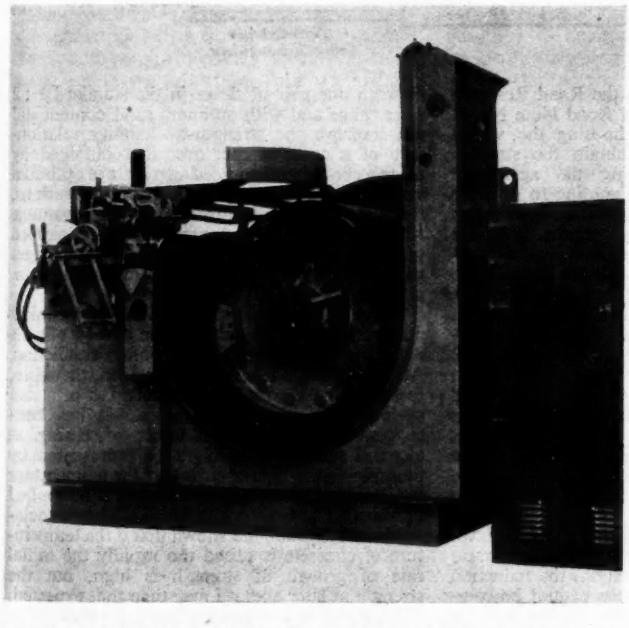
Tube Drawing Bull Block

A DEMONSTRATION of drawing copper tubes at high speed was recently given on a 54in horizontal bull block at the works of the Marshall Richards Machine Company, Ltd., Crook, Co. Durham. In this machine the tube is drawn from a large coil freely supported on a swift, over a floating plug and through an associated reducing die, on to a rapidly rotating block. Successive reductions are made by removing the coil from the block, replacing it on the swift and repeating the operation, using smaller diameter plugs and dies. The machine on which the demonstrations were made is one of the largest made by the firm and is illustrated below. According to the class of work for which they are required these machines are fitted with either a 75 h.p. or a 100 h.p. driving motor, although that demonstrated had a 60 h.p. motor and consequently its drawing speed was lower than would be possible in an actual installation.

In order to give the wide range of drawing speeds required for the machine a variable speed d.c. motor drives a change speed gearbox to make available speeds ranging from 150ft to 1350ft per minute. The motor and gearbox are mounted on an extension of the main bed-plate of the machine and the actual drive to the block is transmitted by a heavy duty worm gear carried on ball bearings. The ball block is not mounted directly on its driving shaft but is carried on ball bearings on a heavy cast steel column in the frame of the machine. With this construction the maximum drawing load can be carried on the outer end of the block without imposing a bending load on the driving shaft. Two alternative forms of tube pulling-in gear can be fitted on the block, one being in the form of a rigid spring steel blade supporting the gripping dog, and in the other the dog is attached through a heavy duty chain.

The swift on which the coil of tube to be drawn is placed is supported on the same saddle as a traversing die box. This traversing saddle assembly runs on heavy slides on the main frame at the side of the bull block. The die box on the front of the saddle is carried on ball and roller bearings and is free to swivel a limited amount in both the vertical and horizontal planes so that the drawing die automatically aligns itself when the tube is being pulled in and during the drawing operation.

A floating plug is used in drawing the tube and the die box accommodates two dies in tandem, the leading die being of the undrawn tube size and the second being the drawing die. The leading die imposes a sufficient load on the tube to ensure that the length between it and the drawing die is quite straight. The traversing saddle is moved by power in both directions and its speed is selected through a gearbox at the rear of the machine, to suit the diameter of the tubes being drawn. The coil of tube on the swift is supported on a number of horizontal rollers and as it is drawn off it is held centrally by pneumatically-operated vertical rollers. The drawn coils of tube are stripped off the block by a compressed-air-operated pusher ring, and provision is made on the machine for fitting hydraulically-operated shears to cut off the end of the tube. During the course of the demonstrations a 1·350in outside and 1·234in inside diameter coil of tube 147ft long was reduced to a 0·375in outside and 0·303in inside diameter tube 867ft long in six drawing operations.



54in tube drawing bull block driven by a variable-speed motor through a gearbox, and having drawing speeds from 150 to 1350ft per minute

Wagon for the Bulk Delivery of Flour

A NEW wagon developed for the bulk transport and delivery of flour was demonstrated recently at the Cheadle Heath works of Henry Simon, Ltd. The chassis of the vehicle demonstrated was a Leyland "Octopus" but it is stated that any other standard 22-ton chassis can be utilised for the wagon, which is shown in one of the illustrations on this page.

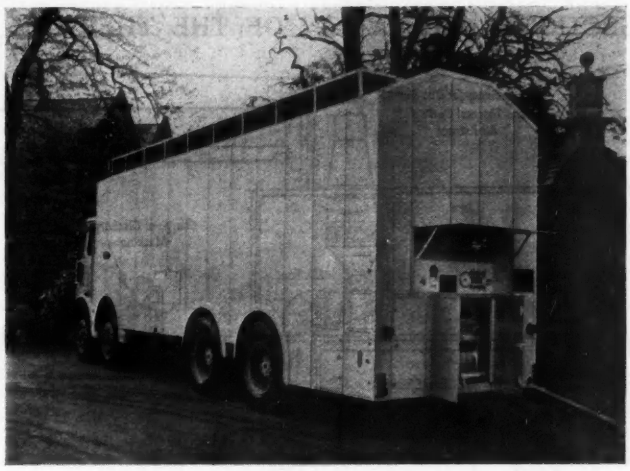
The aluminium alloy body of the wagon is 24ft 6in long, 7ft 5in wide and 11ft 9in high. In the base of the body are three longitudinal hopper bays sloping towards the rear of the wagon and having a 9in wide "Aeroflow" discharger at the base of each. The steep sides of the bays direct the flour on to the dischargers during the final stages of unloading. Doors fitted in the exterior panels permit access to the working parts; and inspection windows and a searchlight enable the operator to check unloading.

The top of the body is fitted with three rectangular loading hatches and a walkway. These loading hatches have rubber seals and are fitted with textile diaphragms which permit the controlled escape of air displaced during loading. The body has a capacity of 850 cubic feet and its holding capacity is about 14 tons of flour.

The "Aeroflow" dischargers fitted at the base of each hopper, and which are used in unloading the wagon, each consist of a shallow trough closed at the top by a porous medium on which the flour rests. Compressed air is introduced into the trough below the porous medium and blows up through the flour mass above. This flow of air aerates and "fluidises" the flour so that it will flow along a shallow slope. A transverse collecting chute equipped with two short "Aeroflow" conveyors at the rear of the wagon receives the flour from the main dischargers and feeds it into two Simon blowing seals which meter it into the main conveying air stream. A supply of air for the dischargers is provided by a positive displacement blower mounted under the framing at the forward end of the body, and air for elevating the flour from the wagon to the bakery is supplied by a second two-stage positive displacement blower. Both of these blowers are driven from a common shaft through vee belts, the drive to the shaft being taken from the power take-off on the gearbox of the vehicle. The shaft also drives, through a transfer gearbox, the chain-driven blowing seal. The rate of discharge can be varied from zero to maximum by adjusting a simple air valve. The makers state that under normal conditions a full load of flour can be discharged in about forty-five minutes.

From the control panel to be seen at the rear of the wagon in our illustration the operator can control the whole of the discharge process without returning to the cab. The principal controls are a remote throttle control for the engine, operating handles for the cut-off slides, selector valve controls for the dischargers and controls for the by-pass valves on both discharging and conveying lines. Below the control panel are doors giving access to the discharge connections to the blowing seal.

The wagon is simple to operate. All that is required is to connect the flexible hose to the blowing seal and to the bakery intake pipe, set the air controls and then apply the power drive.

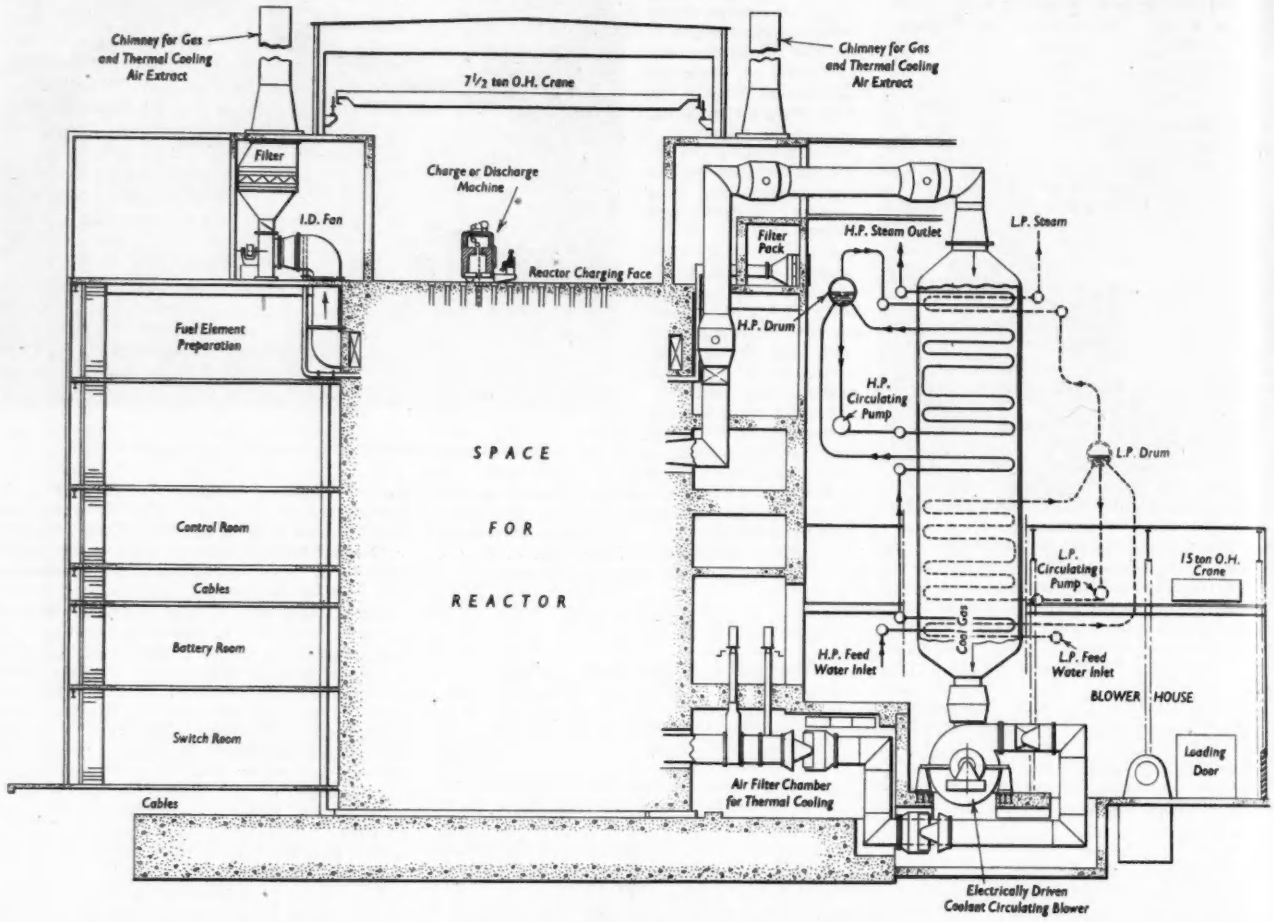


Bulk delivery wagon for flour, showing control panel at rear

Development of Guided Missiles

THIS week a joint official communiqué has been issued by the Ministry of Supply and, in Washington, by the United States Government with regard to the closer collaboration between the United States and Britain in the development of guided missiles. The communiqué states that talks to this effect have recently been concluded between Mr. Charles Wilson, the United States Secretary of Defence, and Mr. Duncan Sandys, the British Minister of Supply. Problems relating to the development of guided missiles were accorded particular attention during the talks, another important matter discussed being the securing of more active co-operation in this field. Such co-operation, states the communiqué, should prove of value in helping both countries to make the maximum productive use of all the scientific and technical resources available, and further, it should serve to accelerate the development and speed up the introduction of guided missiles for the purpose of common defence. Before taking part in the the talks Mr. Sandys made an extensive tour to see something of the progress being made in the various experimental establishments engaged in the development of guided missiles, which are situated in different parts of the United States.

SECTIONAL ELEVATION OF THE THERMAL REACTOR AT CALDER HALL POWER STATION



Atomic Power Station at Calder Hall

In our issue of June 4th last (page 832) we published an article giving an outline of the method of steam generation at the Calder Hall atomic power station. This article was illustrated by a perspective drawing showing the principles of steam raising in four 80ft towers, each containing h.p. and l.p. sections, comprising preheater, evaporator and superheater.

After this article had gone to press another drawing was released for publication and we reproduce it herewith to show the general arrangement of the steam and electrical plant.

High-Strength Concrete

We were recently invited by the Cement and Concrete Association to visit the research and development division and the training centre of the Association at Fulmer. The training courses in reinforced concrete and prestressed concrete and other allied subjects, which are held regularly, form an important aspect of the Association's work, and apart from instruction in the technicalities of subjects such as prestressed concrete, a basic aim is to teach those attending the courses how good quality concrete is made, and hence to promote sound practice in concrete making.

The research and development work carried on at Fulmer covers most aspects of concrete work, except for the study of the chemistry of cement, which is done by the manufacturers. Long-term research and experiments of an *ad hoc* nature are carried out ; there is a chemistry and physics section, a concrete section concerned with the properties of concrete, a structural section,* and a section dealing with special problems of an engineering nature. As an example of some of the recent work at Fulmer, we print below some details of studies on high-strength concrete.

The usual method of mix design used in Britain is that developed at the Road Research Laboratory and described in Road Note No. 4. It consists essentially of choosing the water/cement ratio necessary to obtain the strength required and then choosing the aggregate/cement ratio and aggregate grading to give the desired degree of workability. The actual values of water/cement ratio and aggregate/cement ratio are chosen from tables and curves determined experimentally. No allowance is made for the effect of the type of aggregate or of the aggregate/cement ratio on the strength, but both are taken into account with respect to workability. The method has been found to work well for compressive strengths up to about 6000 lb per square inch at twenty-eight days and reasonably well for strengths slightly above this value, but for substantially higher strengths it has been found that the type of aggregate, the aggregate/cement ratio and the workability have a significant effect on the strength and have to be taken into account.

The Association's investigation has shown that while decreasing the water/cement ratio results in an increase in strength, the reduction in workability that also results cannot be compensated for indefinitely by increasing the cement content and very high strengths can be obtained only with mixes of very low workability. The type of aggregate also has an effect, crushed granite giving higher strengths than flint gravel, the difference becoming greater as the strength increases. In using these principles mixes have been designed for strengths of 7000 lb per square inch which can be obtained in one day without steam curing and up to 14,000 lb per square inch at twenty-eight days, using intense vibration and pressure to compact the concrete.

Tests have also been made on gap-graded aggregates for which it is sometimes claimed that higher strengths can be obtained with equal workability. The results obtained to date, however, indicate that for both irregular gravel and crushed granite aggregates the use of an aggregate with a gap equivalent to material held between one pair of sieves in the standard 1 : 2 ratio range and with optimum sand content did not improve the strength-workability relationship of a concrete mix over that obtained by using a continuously graded aggregate of optimum sand content. These preliminary investigations, it is stated, have not shown any major advantage to be gained by the general use of a gapped grading, though there may well be advantages when the gap is made larger or under particular site conditions.

There is a considerable amount of technical literature on the subject of steam curing, but the data that has been published is often conflicting. An investigation has been undertaken, therefore, to determine the underlying principles of steam curing at atmospheric pressures. It has been suggested that the total effect of curing at elevated temperatures might be represented by multiplying the time of curing by the temperature but attempts to show that this rule can be applied universally have generally failed. The Association's investigation has shown that if the temperature of concrete is raised too rapidly the initial rate of growth of strength is high, but the strength at later ages is lower than that expected. If a certain rate of heating is not exceeded, and the zero of temperature is taken as −10 deg. Cent., the strength of concrete is in fact a function of the product of time and temperature. This time-temperature parameter has been called the " maturity " of the concrete. The maximum rate of temperature rise that has been found to be permissible without affecting this maturity-strength law is one that gives a temperature of 50 deg. Cent. in two hours and 100 deg. Cent. in six hours. This does not, of course, mean that rates of heating in excess of this are not to be used in practice. It only means that if they are the ultimate strength will not be as great as that of normally cured concrete of the same composition. A high rate of heating might well be justified when a high early strength is more important than a high ultimate strength. No actual recession in strength has been observed.

* The structures laboratory at Fulmer was described in our issue of May 25, 1951, at the time of its completion.

Standardisation of X-Ray Apparatus

By V. E. PULLIN, C.B.E.

The main purpose of this article is to suggest the standardisation of three models of X-ray apparatus specially designed for engineering use. The main applications of X-rays are discussed and the article attempts to show that all these applications could be catered for by three standard sets supplemented by an appropriate battery of radio-active isotopes.

A SURVEY of the X-ray apparatus which is now commercially available for industrial and engineering radiography shows that there is considerable diversity in the kinds of equipment on the market. These differences are expressed, first, of course, by the various kilovoltages at which the X-rays are generated; secondly, by the methods of control which, incidentally, are sometimes a little over elaborated, and, thirdly, by the general design which appears to be more and more concerned with achieving a high degree of complexity in the movement of the X-ray tubes. In this respect the apparatus is further complicated in some cases by the introduction of electrical methods of manipulation. Because in the main radiography of engineering structures is now so generally demanded it might not be inappropriate to consider what is the best and most economical apparatus to select for any particular kind of work. Also, whether the conventional commercial kinds of apparatus are really the best and most economically designed to suit modern requirements. It is, of course, to be remembered that radio-active isotopes are now freely available to industry and may in many cases prove both more economical and, in some cases, even more appropriate than X-rays.

The main lines of radiographic applications in engineering—that is to say, the spheres where radiographic methods have the greatest value, are those concerned with welding on the one hand, and those concerned with the critical examination of stressed parts of highly important castings, especially those upon which life may depend, on the other. For example, certain of the vital castings used in aircraft construction are inspected 100 per cent by radiography.

To consider welding for one moment. Here, again, the problem falls into two parts. In the first place, the radiographic inspection of highly important Grade I welds in high-pressure vessels is a *sine qua non*. This particular field lends itself with great facility to X-ray inspection on a 100 per cent basis because the flaws chiefly to be feared in modern high-grade welding of pressure vessel seams are very fine cracks which statistically are usually to be found in the plane of any X-ray shot taken normally to the plate. Incidentally, the detection of indications of such cracks in a radiograph is an extremely difficult matter and calls for a high degree of skill and care in the scrutiny of the film. This is a truth that is not always appreciated as clearly as it should be. It is obvious that it can only be on extremely rare occasions that the X-ray beam passes directly through the crack to produce a well-defined sharp line in a radiograph.

In the examination of Grade I welding, if radiography is to have its maximum value, and it is valueless if it has not, it must be carried out with all the refinements of which the method is capable. It must be precision radiography as far as possible, quite irrespective of time or expense. For this class of radiography within a limiting plate thickness of, say, ½in to 3in of steel, radiography by X-rays has a tremendous advantage. The times of exposure are shorter ; the photographic contrast is better—consequently interpretation is easier and less liable to error than if the plates were examined by means of gamma radiation.

A very large proportion of high-grade welding involves steel plate which approximates to the limiting thickness mentioned, and probably the best all-round X-ray equipment for this work is apparatus having the maximum kilovoltage of 400. In plate thickness of 3in, and upwards, radiography by X-rays becomes rather more difficult in practice and demands ultra high voltages and remembering that the maximum radiographic sensitivity of the gamma radiation emitted by the isotope cobalt 60 is between 3in and 5in in steel, it may be sound practice to adopt this particular source of radiation in such work. But the fact remains that the bulk of high-pressure boiler welding at the moment could, in the opinion of the writer, be dealt with by a 400kV X-ray equipment. The actual radiography of these high-pressure vessels is comparatively a simple matter and calls for very little manipulation of the X-ray set—a few simple movements are all that are required. Rigid stability, of course, is essential. It would appear that too little attention has been paid by manufacturers to the production of a really robust, well-designed, 400kV X-ray set specially designed for engineering use. There is at least one such apparatus on the market, but it does not appear to be as popular or as widely used as it should be.

When we consider the second class of welding we are faced with a variety of factors. We have to cater for the examination of ordinary simple constructional welding, tank welding, ship welding or the welding of small fabricated parts. Here the problem becomes a little more difficult than the one we have just considered, because here the mobility of the tube or the specimen may become important. For example, it may be necessary to take the equipment into the structure of a bridge ; to use it on site in the construction of large storage tanks or other structures, or to take it into a ship, and so on. If this welding is concerned chiefly with comparatively thin plate, as it usually is, then a low-voltage X-ray equipment will suffice, maybe something of the order of 100kV, and the important attributes in its design will be light weight combined with strong and robust construction.

Here, again, it is conceivable that too much attention tends to be paid in modern X-ray equipment to complexity of design to achieve wide variation in the movements of the tube. It is no doubt attractive to be able by the movement of a lever or the pressing of a switch to perform extremely complicated evolutions with an X-ray tube, but one cannot help wondering whether such movements can ever be really necessary in engineering radiography—at any rate, necessary or desirable enough to justify the additional expense involved. Probably after critical consideration it would be found that such extreme flexible adaptability is necessary in only very special cases.

The next point for consideration is the application of radiography to highly important and complicated castings. In this respect it should be borne in mind that it is the highly stressed parts of such structures that are of vital importance. Such parts should be defined both by the user from one point of view and by the foundrymen from another. It may be that in order thoroughly to investigate the soundness of such parts the source of radiation will have to be placed in a confined or very awkward situation relative to the X-ray film. It should also be remembered that in really good radiography the actual alignment of by far the greatest proportion of radiographic shots should be normal to the specimen—even though such a principle may involve extra shots. It is quite true that angle shots in complicated structures are sometimes unavoidable and therefore necessary, but, nevertheless, such shots should be avoided wherever possible because of the inevitable appearance of adventitious shadows cast by variations in thickness in the path of the rays and the difficulty of assessing the geometric projection of landmarks and defects. Furthermore, the likelihood of reliable detection of fine flaws is lessened. In order to achieve normality of alignment it may be quite impossible to use an X-ray tube, and recourse should then be made to one of the radio-active isotopes which by virtue of its size and mobility may be inserted in places quite inaccessible to an X-ray tube. The facility with which it is now possible to manipulate an X-ray tube into a large variety of different positions has resulted, in the author's experience, in many undesirable angle shots which have proved exceedingly difficult to interpret with confidence.

The main purpose of this article is to suggest that the question of the standardisation of X-ray equipment design for the various main engineering needs might very well be the subject of consideration by such a body as the B.S.I. Such standardisation would probably be of inestimable advantage to the X-ray equipment manufacturer and also to the prospective customer who very often is led to purchase unsuitable apparatus because of lack of knowledge or reliable guidance. Thus it might be possible to standardise on, say, three models of X-ray apparatus designed for engineering use—a 400kV equipment for boilermakers and heavy steel engineering, a 250kV for light alloy inspection and a 100kV robust lightweight model for site work and shipyards. Such equipment, supplemented by a stock of appropriate radio-active isotope sources, should enable all ordinary radiographic work to be undertaken with reliability and success. It is realised, of course, that from time to time special designs of equipment would be necessary to deal with unusual problems and that in certain cases 1,000,000V or 2,000,000V X-ray sets would be necessary, but the three models outlined here would cover most of the requirements. No cognisance has been taken here of the use of linear accelerators, cyclotrons, &c., which at the moment fall rather outside the range of practical politics.

The question of the use of appropriate radio-active isotopes, their quantity, storage, and method of use is a subject that has been discussed on many occasions and about which information is freely available at the Atomic Energy Research Establishment. There is, however, one point of interest which should be mentioned. In view of the tendency to shorten exposures by the use of high concentrations of these isotopes, the question of manipulation remains a very serious one from a safety point of view, and in this respect it is noteworthy that there is on the

market a particularly attractive piece of apparatus which is used for the storage of very large concentrations of, say, Cobalt 60, up to 5 curies, and which by means of an electrically remote controlled wire holder can manipulate the unshielded specimen into a given position without danger. The advantages offered by this apparatus should help a very great deal to facilitate the storage and use of high concentrations of high-energy isotopes. This particular apparatus is coverd by patents in the U.S.A. It is also made and sold in this country.

A new method of recording radiographs is now under intensive development. It is known as Xerography, by which process the photographic side of the subject, developing, fixing, washing and printing, is entirely eliminated. The image is formed by means of the variation in an electrical charge governing the thickness of a fine powder deposited on a photo-conductive insulating material such as a film of selenium. The charge is retained until exposed to light or ionising radiations. The image is formed by the differential discharge occurring when the film is subject to variations in radiation intensity. The results so far obtained are impressive and no doubt the method will have many applications in the engineering industry, particularly in cases where radiography is used as a consultative *ad hoc* method of investigation. For example, in the investigation of thermionic valves, switchgear, or the first products of a foundry. Its uses in routine inspection processes are not at the moment capable of exact definition, but may conceivably develop at a later stage. There is no doubt, however, that the method has great potential value. Its usefulness will probably be in the works laboratory rather than in the production syndrome.

Mechanical Handling Exhibition

No. II—(*Concluded from page 854, June 11th*)

THE fourth Mechanical Handling Exhibition which began at Olympia, London, on June 9th, will close tomorrow. Here, we conclude our description of some of the equipment shown.

The fork-lift trucks exhibited by Conveyancer Fork Trucks, Ltd., Liverpool Road, Warrington, include a number of machines for special-purpose use. One of these trucks with a 4000 lb capacity at 20in load centre is fitted with a flameproof diesel engine power unit and has been built to the requirements of oil companies for use in fire hazard areas. As in the case of several other fork-lift trucks on the stand, it has a hydraulic torque converter transmission.

One of the 4000 lb capacity electric fork trucks on the stand is shown fitted with a hydraulically operated rotating reel clamp for handling paper reels. Another exhibit of interest is the 6000 lb at 20in. load centre machine shown in Fig. 15 and fitted with a Head Wrightson "Brosius Manipulet." This truck is particularly intended for use in the forging industry and has a special mast complete with the attachment. The manipulator is hydraulically operated from the main hydraulic circuit of the machine, which incorporates an accumulator. The billet holding jaws can be rotated through 360 deg. in each direction. Through the normal mast operating system the attachment can be raised or lowered as required and tilted back through an angle of 10 deg. or forward 3 deg.

The power transmission equipment displayed by Crofts (Engineers), Ltd., Bradford, includes a new development in the firm's geared motor unit, known as the "Rite-speed" range. In these units interchangeable high-speed wheels and pinions provide a wide selection of output speeds from 21 to 595 r.p.m. with speed ratios varying from 3/1 to 75/1.

A conveyor driving head assembly illustrated in Fig. 16 embodies several of the firm's standard products. A new design of positive springless variable-speed pulley transmits power through a high ratio, double reduction worm gear which has overall reduction ratios of 3100 to 1.

An 8in "Airflex" clutch coupling is fitted between the output shaft and a light-duty fabricated steel conveyor pulley. This conveyor pulley is fitted with a silent ratchet backstop, and while the conveyor is in operation the backstop automatically frees itself from a pawl. The backstop prevents the belt conveyor from running back, as the pawl immediately engages the ratchet, locks the shaft in place and is held in position until forward power is again applied.

The positive springless variable-speed pulley incorporated in the drive consists of two cone-faced discs, one fixed and the other sliding. The sliding cone is actuated by a screwed housing through a compact single train of gears on the end of the screwed housing and connected by a flexible shaft to the operating screw in the adjustable slide base. In operation, the centres are increased by movement of the motor platform away from the driven shaft by means of a handwheel, the cones opening out automatically in unison with this increase as the ropes move down the cones. This permits the vee ropes to take up the progressively smaller pitch diameters until at extreme centres the vee rope is at the smallest pitch diameter; consequently the drive is running at minimum speed. When an increase in speed is required the centres are reduced by operating the handwheel in the reverse direction.

A new lorry-mounted crane made by Chamberlain Industries, Ltd., Staffa Works, London,

Fig. 17—10-ton lorry-mounted crane with hydraulically controlled, mechanically driven motions

E.10, has a maximum capacity of 10 tons at 10ft radius when fitted with a standard 30ft jib. In this crane (Fig. 17) the upper frame consists of two parallel rolled steel channels to which are welded steel "A" frames. A Perkins "L.4" diesel engine with a fluid flywheel is mounted on a trolley which runs in the two horizontal channels of the frame. The engine drives two layshafts mounted on the left-hand side of the upper frame, on each of which are three hydraulically operated clutches. The hoisting and luffing drums and the slewing pinion are driven through worm reduction gears and the input shaft to each gear box is driven by a chain, which passes round the clutch on each layshaft and over an idler sprocket. Hydraulic actuation of the clutches gives positive drive on all three motions in either direction.

The upper frame is mounted on three pairs of

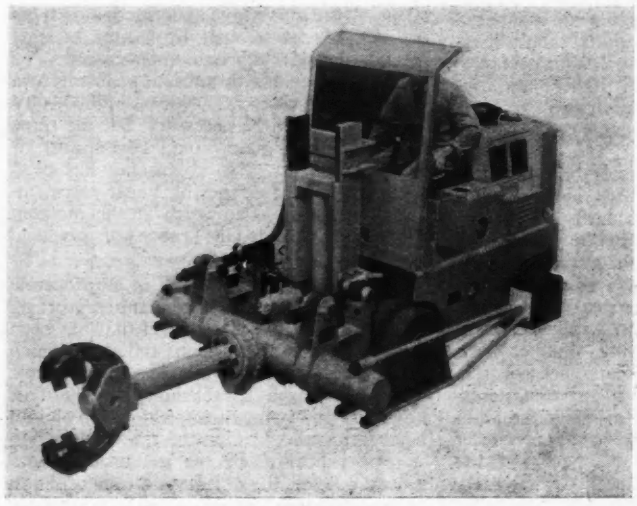


Fig. 15—6000 lb fork lift truck fitted with a forging manipulator

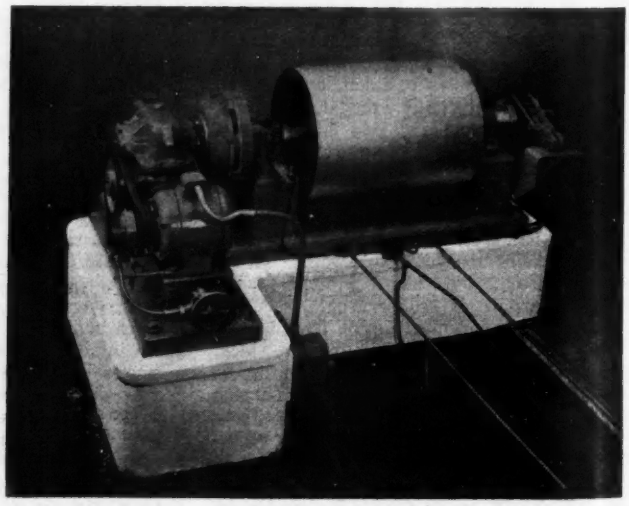


Fig. 16—Conveyor driving head assembly with an "Airflex" clutch and positive springless variable speed pulley

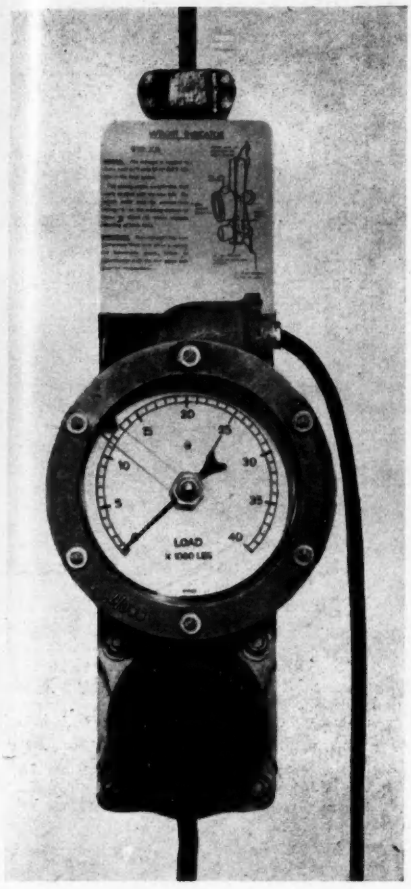


Fig. 18—Deadweight indicator for use on portable oil drilling rigs. In this instrument the load is transmitted through rollers to a hydraulic cell

rocking hook rollers running in a vee-grooved slewing ring mounted on the lower frame. In the lower frame, made from rolled steel sections and boiler plate, are fitted the units of an A.E.C. "Mammoth Major" chassis. The standard jib is 30ft. long and may be fitted with extensions up to 60ft.

The engine is mounted on two light rolled steel beams, to the ends of which are fitted four trolley wheels. These wheels run in two members of the upper frame, to the back of which are fitted two hinged legs. These legs can be lowered to a horizontal position, and when the engine controls, fuel lines, &c., are disconnected the power unit can be withdrawn.

In the motion gear the layshafts, each fitted with three multi-plate disc clutches, are mounted on a sub-frame on the side of the main frame, and this unit can be withdrawn completely for overhaul. Each clutch is hydraulically operated by a hydraulic ram of 1⅜in internal diameter and 1in stroke through a mechanical linkage. The linkages are connected to the brakes on the reduction gearboxes so that these are automatically disengaged as a clutch is engaged.

The motion gear has been so designed that when the crane is lifting one layshaft is driving, and when luffing up the other layshaft is driving. Neither layshaft, therefore, transmits more than a proportion of the full power of the engine.

A vane hydraulic pump of 5 gallons per minute nominal output at 1000 r.p.m., mounted at the front end of the lower layshaft, provides hydraulic power for clutch operation at a maximum pressure of 1000 lb per square inch.

The basic hoist and luffing winch units are identical and each consists of a high-duty cast iron drum mounted on an extended shaft, carried at one end in a 40 : 1 worm reduction gearbox, and at the other end by a roller bearing mounted in the sub-frame. A driving sprocket is mounted on one end of the worm shaft, and on the other a 12in standard automotive clutch is mounted, the housing of which is bolted to the sub-frame. Under static conditions the clutch is engaged and prevents the worm shaft, and therefore the drum, from turning. The luffing drum is fitted with a ratchet wheel and pawl to prevent overrunning, the pawl being disengaged mechanically.

For the slewing gear a 30 : 1 worm reduction gear is mounted on the bottom of the upper frame, between the two main members and operated by a clutch and brake mechanism similarly to the winches. The worm shaft extends downwards, carrying the slewing pinion and an outrigger bearing at the lower end. This pinion engages with machine-cut teeth on the slewing ring.

The motion gear is controlled by three levers, each of which engages by cams two single-acting piston valves, admitting hydraulic oil under pressure to the appropriate clutch rams.

A recently introduced electronically controlled weighing, measuring, filling and recording equipment is being demonstrated by the British Tabulating Machine Company, Ltd., 17, Park Lane, London, W.1. With this equipment plant can be arranged to record automatically, in predetermined sequence, the tare of containers, fill them to within plus or minus 0·22 per cent of the required weight, and then print the net weight of material poured into each container, together with the batch number and serial number of the container. At the end of each batch of material weighed out the apparatus prints a further slip showing the total amount put through the plant.

The equipment exhibited has been arranged to demonstrate one simple application of the new electronic apparatus which can be built to suit specific requirements in the weighing and feeding of solids, powders, fluids and gases.

In Fig. 18 we illustrate a deadweight indicator primarily developed for use on portable oil drilling rigs by the B. and A. Engineering Company, Ltd., 50 Pall Mall, London, S.W.1. This instrument is fitted on the deadline rope of a drilling rig and in it the load is transmitted through freely rotating rollers to a hydraulic cell, which is completely sealed. The 6in diameter dial is calibrated and shows the total load in the hook of a four-part rope system, up to 25,000 lb. A movable setting pointer provided on the dial enables the drill penetration load to be set and worked till the main total load on the drilling set is relieved. Installation is quick and simple by means of a rope clamp which is fixed to the deadline rope, and means of adjustment are provided to adapt the indicator for ½in and ⅝in diameter wire ropes.

The method of transmitting the load ensures permanent accuracy, as it is unaffected by rope deformation caused by overtightening the clamp, and no frictional losses are incurred on load bearing parts. The gauge incorporates a shock and vibration damper, and has a dial light fitted.

The makers point out that although the indicator was primarily developed for portable drilling rigs, it can be freely adapted for use on equipment or plant where it is necessary to measure the force in ropes and in place of the dial on the unit a transmitter can be fitted which activates a remote electrical load indicator dial which can be mounted in any desired position.

The straddle carrier, developed for use in transporting steel sections, pipes, bars, boilers, &c., in the heavy industries, which is made by the British Straddle Carrier Company, Ltd., 7, Chesterfield Gardens, London, W.1, is illustrated in Fig. 19. This machine consists essentially of a heavy steel arched frame structure with the controls and drive mounted on the top platform. It is made with eight alternative load aperture sizes from 47in wide by 54in high to 59in wide by 60in high.

The hooks, set at each corner of the aperture, are used to pick up the load to be transported, and are actuated by a chain drive from cross shafts driven through reduction gearing by the main 65 b.h.p. engine. These hook members move on rollers on substantial guide frames which also serve to prevent damage to the lifting tubes when a load is being picked up.

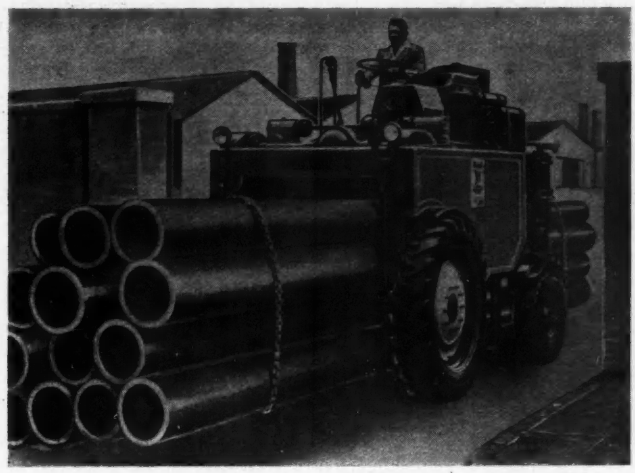


Fig. 19—Straddle carrier for heavy industrial use, driven by a 65 b.h.p. engine and capable of handling loads of 7 tons

The machine is designed to handle loads of up to 7 tons and has a maximum forward speed of 25 m.p.h. Steering is effected through the two rear wheels and the machine has an inside turning radius of 9ft.

Ransomes and Rapier, Ltd., of Ipswich, is showing a new addition to its range of "Super Mobile" cranes. This crane is mounted on pneumatic tyres, has a full-circle slewing superstructure, and handles 10-ton loads at 10ft radius, giving 5ft 6in clear outreach. When it is fitted with long jib extension, as exhibited, it is capable of lifting 2½ tons 50ft at 26ft radius. The drive is petrol-electric or diesel-electric, with variable voltage control and separate motors for the hoist, derrick, slew and travel motions and steering. A cargo-handling jib is available for fitting to the machine when it is required for dock use for discharging from hold to quay.

A selection of the hydraulic equipment it

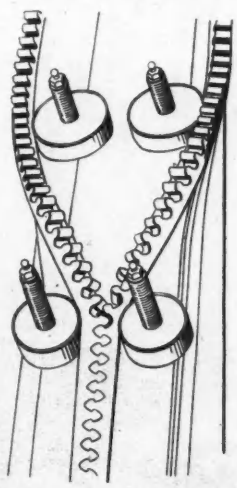


Fig. 20—Diagram of closed-belt conveyor-elevator showing belt spread open for filling and arrangement of closing rollers which lock teeth of belt together

makes for use on mechanical handling plant is shown by Keelavite Rotary Pumps and Motors, Ltd., Allesley, Coventry. This company recently developed a range of fixed capacity pump/motor

units with displacements up to 50 cubic inches per revolution for power transmissions from fractional to 250 h.p. at 2000 lb per square inch. The complete range is developed from six basic designs and each unit will function as a pump or motor in either direction of rotation without any modification in assembly.

This company is also showing examples of a new range of standard stroke hydraulic cylinders for different forms of mounting and made in five bore sizes from 2in to 6in suitable for operating pressures up to 1500 lb per square inch. A working exhibit demonstrates one of the firm's multiple-valve blocks controlling a constant torque variable speed rotary drive and the synchronised movement of out-of-balance loads using a flow-dividing equipment.

An exhibit of interest on the stand of Rownson, Drew and Clydesdale, Ltd., 225, Upper Thames Street, London, E.C.4, is a " Zipper " closed belt conveyor-elevator which the firm is making under licence. This conveyor-elevator is designed round a belt illustrated diagrammatically in Fig. 20. The belt comprises a flat, endless base belt of rubber and fabric with integral flexible rubber side walls on the upper edges of which are moulded interlocking rubber teeth.

The drawing shows how the belt is closed and opened with a minimum of tooth wear. In travelling from the inside guide rollers to the closing rollers, the spaces between the teeth are spread and the teeth mesh without rubbing contact. As they pass the closing rollers, the teeth lock firmly. The belt is opened in reverse manner for the return run of the conveyor, for passing round pulleys, and for depositing the load. Material is fed into the channel formed by the vertical side walls of the moving belt which are then automatically closed by " keying " the teeth by the rollers. With the column of material sealed in the belt it can be carried at high speeds, without spillage, horizontally, vertically, or up inclines and round bends.

" Bevatron " Particle Accelerator, California University

(*By our American Correspondent*)

The "Bevatron " at the University of California Radiation Laboratory in Berkeley, which is said to be the world's most powerful particle accelerator, is now in operation, approximately six years after its design was first conceived and four years after construction began. It cost* 9,000,000 *dollars, provided by the U.S. Atomic Energy Commission. The first successful acceleration was achieved on February* 15*th, when the protons reached* 20*MeV. The energy was built up gradually until* 4700*MeV was reached on the evening of March* 9*th. Further trials, leading up to the design energy of* 6250*MeV are in hand.*

AT an energy of 6250MeV, the particles emerging from the " Bevatron " are equivalent to cosmic rays of the medium energy range. Early research with the machine will be devoted to the identification of the nuclear particles generated when these protons from the machine bombard target atoms. In addition to the proton beam, a secondary beam of neutrons, ranging in energy up to 6250MeV, is generated. These neutrons are dislodged when the protons strike target nuclei, and the neutron beam can be used for special research bombardments. Initially, attention will be focused especially on mesons created by the collision of high-energy protons with particles in target nuclei. The production of mesons is considered to be one of the chief missions of this and other modern high-energy particle accelerators.

The " Bevatron " itself cannot accelerate particles from a " standing start " or even at low energy. Therefore particles have to be accelerated to a relatively high energy in several stages. The ion source for the " Bevatron " is similar to that commonly used for a cyclotron. It consists of a small chamber filled with hydrogen gas and containing an electrical arc. When the arc is discharged electrons are removed from the hydrogen atoms. The resulting hydrogen nucleus is a proton, with a positive charge. These protons are guided electrically into position in the accelerating tube of the Cockcroft-Walton machine.

It is of interest to note that one of the subsidiary components of the present " Bevatron " is an up-to-date version of the first effective " atom-smashing " machine, which was developed by J. D. Cockcroft and E. T. S. Walton at the Cavendish Laboratory in 1929. The Cockcroft-Walton machine starts the protons on their journey by accelerating them to an energy of 0·5MeV. From the Cockcroft-Walton machine the protons are fired into a linear accelerator (Figs. 2 and 3). It consists of a steel tank, 3ft 6in diameter and 19ft long, containing a copper cavity. In the centre of this cavity are small " drift tubes " through which the protons are aimed. High-frequency electrical charges on the drift tubes cause the protons to gather speed and energy, and, on emerging, they have an energy of 10MeV. On leaving the linear accelerator the protons pass between two strong focusing magnets which " bunch " the particles together.

The next problem is to get the fast-moving protons into the circular orbit of the " Bevatron " accelerating chamber in the right position and moving at the right angle to be caught by the magnetic field. If left alone, the 10MeV protons would pass through the chamber and into the inner side of the magnet yoke. The positioning of the protons is achieved by the so-called inflector, which consists of two plates of steel, precision-machined in a circuit of 18ft radius with a 35 deg. arc. The two plates are placed parallel to each other in a vertical position. They are ⅜in apart and are charged with 70kV. As the protons travel between these two plates their paths are bent gradually by the electrical field. By the time they have passed the inflector the protons have been guided to the required orientation and position for their entry into the " Bevatron " accelerating chamber. At this point the large magnet takes over the further guidance of the particles.

The protons are required to circle the chamber inside the magnet some 4,000,000 times in approximately 1·85 seconds ; to ensure that they complete this journey without hitting the sides of the accelerating chamber they must be kept to a prescribed orbit, within a few inches. When the protons enter the accelerating chamber the magnetic field is relatively weak—about 300 gauss. It is just strong enough, however, to guide the protons around the chamber in the right orbit. As the protons gather speed and energy the magnetic field is strengthened by increasing the current in the magnet coils to keep the particles in their specified orbit : the magnetic field reaches a peak strength of 15,500 gauss at the end of the journey of the protons.

The magnet is built in four sections or quadrants. Between each quadrant are spaces which allow access to the accelerating chamber for the mounting of auxiliary equipment. The outside diameter of the magnet, which is believed to be the largest in the world, is 135ft ; the diameter at the centre of the accelerating chamber is 120ft.

* The name " Bevatron " was chosen to indicate that this machine is capable of accelerating nuclear particles to energies in the " billion electron volt " range, where " billion," in accordance with American numeration, means 1,000,000,000.

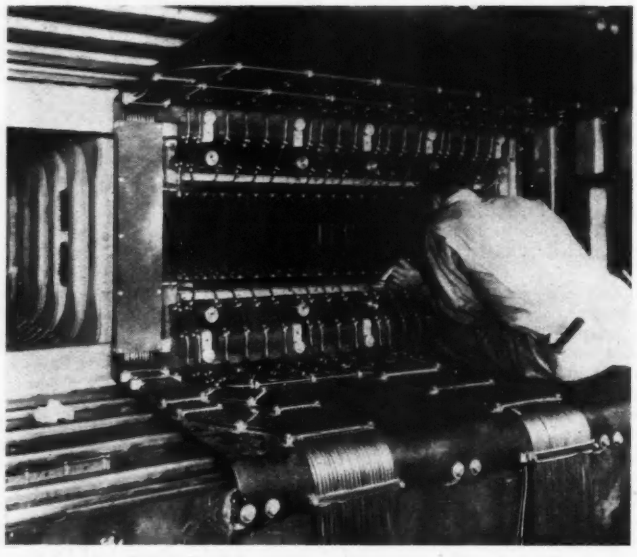


Fig. 1—Installation of pole face windings in aperture of large " Bevatron " magnet

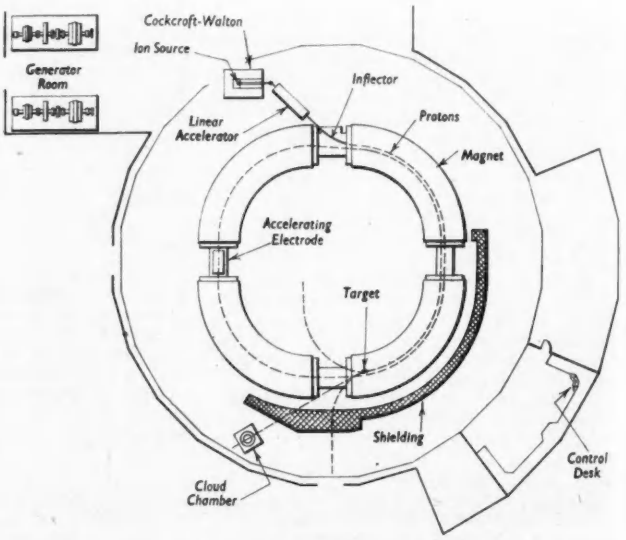


Fig. 2—Diagram of " Bevatron " installation at the University of California

It is 14ft high and is commonly described as "doughnut"-shaped. The steel yoke is 20ft wide and the total weight of the magnet is about 9000 tons. The yoke of the magnet is composed of laminated pieces of steel which are bolted together. The horizontal yoke members each weigh 22 tons, and the vertical ones weigh 4 tons. A total of 140,000ft of 2in copper cable has gone into the winding of the magnet (Fig. 1). Some 15,700 tons is exerted when the magnetic poles begin to pull together.

The accelerating chamber provides free space in which the protons can travel inside the magnet. It is an evacuated rectangular chamber made of stainless steel forming a complete circle inside the magnet. The orbit in which particles circle the chamber is 400ft long. Boosts of energy are given to the protons by means of an electrode inside the accelerating chamber, controlled by a high-frequency oscillator which feeds power to it. The electrode and the oscillator are situated at one of the spaces between the magnet quadrants. The amount of energy which the particles receive from the electrode on each circuit averages about 1300eV. When protons initially enter the accelerating chamber the oscillator has a frequency of 400,000 c/s, and by the time the particles end their journey it has a frequency of 2,500,000 c/s. When they enter the accelerating chamber the protons travel at a speed of 27,200 miles per second. They reach a speed of about 184,400 miles per second or 99·2 per cent of the speed of light, at 6250MeV. The "Bevatron" does not operate continuously, but rather does so in pulses. The acceleration of each pulse of protons requires about 1·85 seconds. Each pulse contains about 100 million protons, and there are about ten pulses per minute. In the first few hundred turns around the magnet many of the protons originally injected are lost. However, enough protons remain to yield an intense beam.

In order that they may be accelerated the protons must travel in a vacuum. The "Bevatron" vacuum system is believed to be the largest and most complex high vacuum system now operating. It extends from the Cockcroft-Walton accelerating tube through the accelerating chamber of the "Bevatron," and its individual components are sealed together with a large number of gaskets. The total volume of the vacuum system is about 12,000 cubic feet, and the vacuum achieved is about 1/100 millionth of an atmosphere. The vacuum is obtained by means of seven mechanical pumps and twenty-four large oil diffusion pumps.

The operation of the electromagnet requires very large amounts of electrical power. Two generators, each equipped with a 60-ton flywheel, make available 100MW of power to the magnet each time a group of protons is accelerated. This power, of course, is needed only during the 1·85 second intervals of particle acceleration, and the stored energy is used to build up the magnetic field during this period. About 80 per cent of the power is returned to storage in the flywheel during each cycle. Losses in power occur and are made up by two 3500 h.p. motors drawing continuously on a 12kV, 600A feeder line supplied by the Pacific Gas and Electric Company.

For cooling purposes two large blowers, each having a capacity of 310,000 cubic feet per minute, are used. The blowers suck air through an air filter in the wall of the building and blow it through a tunnel underneath the magnet. The tunnel is 8ft high and 20ft wide. The problem of shielding is not a serious one in the early operations of the machine, since the number of particles accelerated will be small. However, in anticipation of the use of a higher intensity beam, shielding is now being constructed around the machine. It will comprise a solid wall of heavy concrete, 15ft high and varying in thickness from 5ft to 10ft. It is estimated that the concrete wall will weigh some 900 tons when completed.

In conventional cyclotrons the beam is deflected out of the accelerating chamber by magnetic and electrical means. In the "Bevatron" no system has been developed for deflecting its powerful beam. Instead, at a certain moment, the oscillator is turned off while the magnetic field continues to increase. Then the protons are forced by the field to spiral inward, striking a target at the inner side of the accelerating chamber. The powerful protons knock protons, neutrons and mesons out of the target nuclei, and these particles then pass through a thin window in the steel wall of the chamber. Some of the original protons also scatter out along with the secondary particles. Apparatus employed to detect the beam includes counters, photographic emulsions, and cloud chambers. The continuous cloud chamber which has been built especially for "Bevatron" work is 4ft by 8ft by 7in high. The bottom of the chamber is cooled by 500 lb of dry ice. On top of the chamber are trays from which alcohol evaporates. The alcohol vapour travels down toward the dry ice, getting cooler in the process. When an atom passes through a 3in layer just underneath the alcohol trays the cooling alcohol vapour will condense into vapour trails along the path of a charged nuclear particle. In preliminary operations the cloud chamber will be moved around in the "Bevatron" beam to determine its characteristics and the scattering of the beam, and to establish the points at which shielding needs to be heaviest.

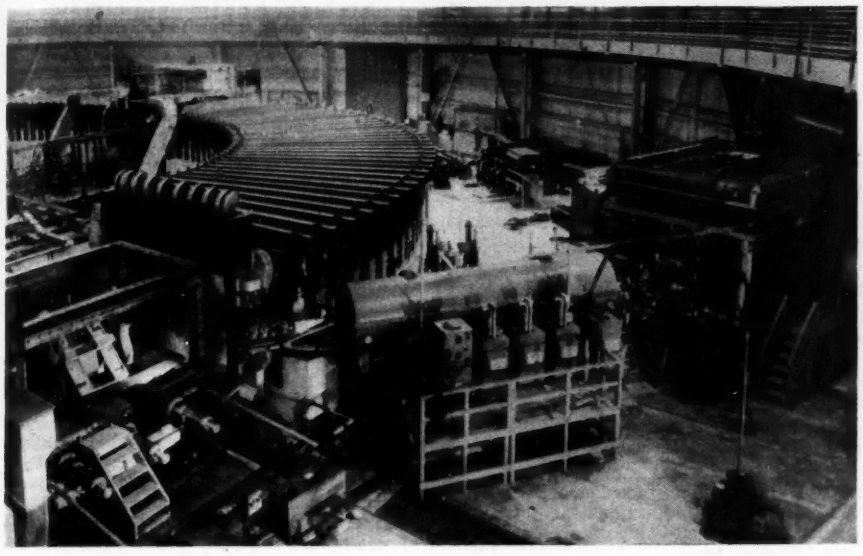


Fig. 3—Partial view of "Bevatron" installation with linear accelerator and Cockcroft-Walton machine in the foreground

Withdrawable-Element Flush-Fitting Relays

A FORM of flush-fronted, withdrawable relay has been developed by A. Reyrolle and Co., Ltd., Hebburn, Co. Durham, to combine the pleasing appearance of flush-fitting cases with the accessibility, for maintenance, of projecting cases.

The flush-fitting cover of this relay has a window through which the mechanism and nameplate of the relay are visible. On removing the front cover by loosening two knurled screws the relay movement can be withdrawn, for maintenance, on a captive carriage to the position shown in Fig. 1, where the mechanism is as accessible as it would be in a projecting relay. All the electrical connections to the relay movement are maintained in the withdrawn position by the flexible connectors that can be seen in Fig. 2. We learn that the principle described here can be applied to most standard Reyrolle relays and that it is at present available in single-pole and horizontal triple-pole forms.

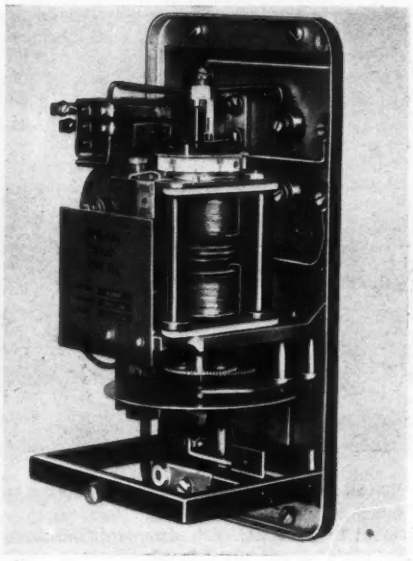


Fig. 1—Relay with cover removed and movement withdrawn for maintenance

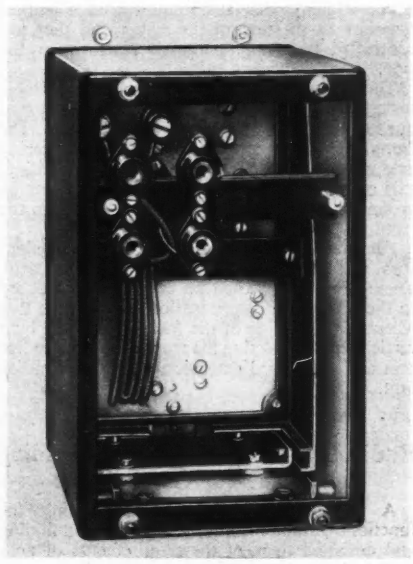
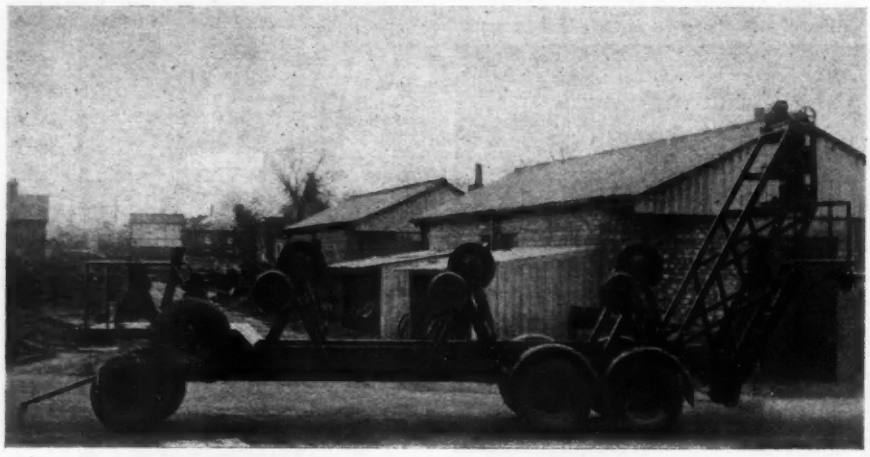


Fig. 2—Back of relay showing flexible connectors. This relay is fitted with a "Perspex" cover for demonstration purposes only

Cable Stringing Trailer

A PHOTOGRAPH we reproduce on this page shows a special trailer designed and built by Cranes (Dereham), Ltd., Dereham, Norfolk, for stringing overhead power transmission lines. This trailer was built for the Mexican Light and Power Company and is arranged to pay out three cables simultaneously as the trailer is drawn forward by a tractor. It is designed to carry a maximum load of 10 tons.

The flat main deck of the trailer is sloped down at the rear, where two hinged ramps are provided for loading purposes. A hand-operated winch at the forward end above the front axle



10-ton, six-wheel trailer for stringing three power cables simultaneously whilst being drawn along by a tractor

is used to hoist the cable drums up the ramp. The cable drums are carried on three shafts spaced equally along the length of the deck and supported on arms pivoted in the top of "A" frames on the side members of the chassis. The ends of these arms are supported by screw jacks through which the drums on their shafts are raised clear of the trailer deck during the stringing operation.

To control the speed at which the cable is paid out an internally expanding brake is fitted to each drum shaft. The drums of these brakes are geared to the shafts and are controlled by levers grouped at the front end of the trailer. Three cable guides are mounted on a superstructure at the rear of the trailer and they are controlled from an operator's platform at the side.

The trailer has a form of suspension suitable for cross-country work and of a design developed during the war for tank recovery vehicles. The front wheels are mounted on a single steering axle which is also pivoted about the longitudinal axis of the trailer to allow articulation on rough ground, no springs being employed either on the front or rear axles.

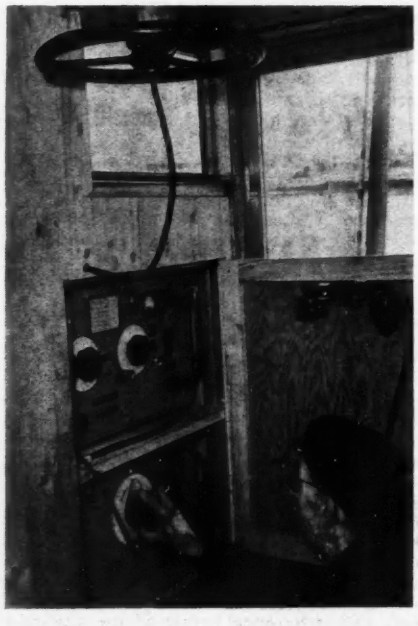
Each rear wheel is carried on an independent stub axle supported by a trailing radius arm. These arms are pivoted on cross tubes attached to the frame and compensation between the two wheels on each side of the frame is effected by a vertical link connecting the rear of the front radius arm and a forward extension of the rear radius arm.

Radiotelephony and Direction-Finding Equipment for Small Ships

A NEW radio installation, combining the functions of radiotelephony and direction finding and designed to meet the requirements of near and middle-water fishing vessels, is being produced by the Marconi International Marine Communication Company, Ltd. It is known as the "Guillemot/Renown/Seapilot" installation, and it provides full facilities for radiotelephony transmission and reception and for direction finding.

The "Guillemot" transmitter, designed only for radiotelephony working, is crystal-controlled and operates in the frequency band of 1·6 to 2·85 Mc/s. This coverage is subdivided into six sections selected by a switch and six pre-selected spot frequencies can be provided for. Power is obtained from 24V accumulators, and the power output to the aerial, unmodulated, is 14W. Operational controls have been kept to a minimum and, apart from the "On/Off" switch, they consist only of the aerial tuning circuit control, and the frequency selector switch. Both the frequency controls are fitted with dials large enough to be operated while wearing gloves.

The "Renown" receiver is a seven-valve superheterodyne equipment specially designed for use with a rotating loop aerial to provide both reception and direction-finding facilities. It is fitted with a built-in loudspeaker and covers three frequency ranges of 131 to 45 kc/s, 375 to 1250 kc/s, and 1154 to 3400 kc/s, giving coverage of marine frequencies, including those used for the transmissions of the "Consol" position-fixing system and the B.B.C. weather reports, forecasts and warnings, as well as those on which the coastal radio-beacon stations transmit. The controls have been kept to a minimum and made simple to operate. The frequency band selection switch, tuning and volume controls, have all been provided with easily handled knobs. The receiver and transmitter, being of approximately the same dimensions, may be fitted one above the other, as illustrated, to make a suitable installation for the small wheelhouse. The receiver also derives its power from 24V batteries, and has a built-in power pack to provide high-tension voltage.



Radiotelephony and D.F. installation on the Seine net drifter "Progressus." The rotating loop aerial is mounted above the wheelhouse

The aerial used for direction-finding purposes is a single-loop rotating frame with a handwheel and pelorus scale. An output socket is provided on the front of the receiver so that headphones can be plugged in when taking bearings.

While the complete "Guillemot/Renown/Seapilot" installation is being marketed by the Marconi Marine Company as a single unit, individual "Guillemot" transmitters and "Renown" receivers can be obtained separately.

African Engineering News

(By Our South African Correspondent)

South African Timber Industry

Plans to make South Africa independent of overseas timber supplies are given in a Union Government report to the Food and Agriculture Organisation of the United Nations. The State afforested area in the Union is to be extended from 560,000 acres to 1,250,000 acres, of which 1,000,000 acres will be conifers. The present annual yield of soft wood timber from State plantations is approximately 20,000,000 cubic feet This is to be progressively increased from year to year up to a future total of some 180 million to 200 million cubic feet per year. During the past five years the average annual rate of afforestation by the State was approximately 15,000 acres. The Department of Forestry has set down as its goal an annual rate of afforestation of 30,000 acres to 35,000 acres. South Africa is at present producing about 62 per cent of its timber requirements, including mine timber. The total output from State, communal and private plantations in 1950 was 100,534,000 cubic feet, while total gross imports of wood and wood products for that year were 61,422,000 cubic feet.

Industry in the Central African Federation

Industry's role in the Federation of Central Africa is emphasised in a survey recently issued by the Federation of Rhodesian Industries. According to the survey, success or failure of the Federal State will depend on the success or failure of industry within the Federation. The report also makes reference to the fact that secondary industry in Southern Rhodesia has increased its gross output from just over £8,000,000 in 1938 to an estimated £128 million, sixteen-fold in sixteen years.

Contemporaneously with this report, it is reported from Salisbury, where the Hydro-Electric Power Bill had passed its second reading in the Federal Parliament, that the hydro-electric scheme on the Kafue River in Northern Rhodesia is regarded by the Federal Parliament as being, in view of the power needs of the copper belt, the most urgent of the schemes which have been examined, which include the Kariba Gorge scheme on the Zambesi and the Shire River scheme in Nyasaland.

An assurance was given, however, that the process of financing all three schemes was going well. Already provision has been made for the expenditure of £350,000 on the barrage of the Shire scheme during the next three years and it should be ready by 1956. An additional £170,000 had been placed on the estimates for a further investigation.

Cement Factory in Southern Rhodesia

A £1,500,000 factory, which is expected to produce some 100,000 tons of cement a year is to be erected near Salisbury, the project being sponsored by the United South African Portland Cement Company and the Associated Portland Cement Industries of Britain. The factory will be situated at Donnybrook, near Salisbury, and will work limestone deposits on about 25 acres proved on Sternblick Farm. It is expected that nearly all the cement produced will be sold in the Salisbury area.

Industrial and Labour Notes

Railway Lodging Turns

On Thursday of last week an "unofficial" delegate conference of locomotive drivers and firemen employed in the Eastern and North-Eastern Regions of British Railways decided to urge strike action in the two regions on Sundays as a protest against the introduction of new lodging turns. It will be recalled that a few weeks ago the executive of the Associated Society of Locomotive Engineers and Firemen was directed, at the society's annual conference, to initiate discussions with the British Transport Commission with a view to bringing to an end the system of lodging turns.

Last Friday, the general secretary of the Associated Society of Locomotive Engineers and Firemen, Mr. J. G. Baty, issued a statement about the "unofficial" delegate conference. The statement said that, in the view of the society's executive committee, the recommendation to indulge in Sunday token strikes represented flagrant disloyalty to the society and was contrary to the decision of its recent annual conference. The proposed action was all the more unfortunate, the statement continued, by virtue of the fact that the branches had been made aware of the urgent steps taken by the society to have the question of the total abolition of lodging turns discussed at national level. The statement went on to say that such action as that suggested by the unofficial conference was bound to undermine the authority of the organisation and to prejudice consideration of "other vital matters" at present on hand. Any disloyalty of the kind suggested, the statement added, would, in the event of its materialising, call for the serious consideration of the executive committee, since the undermining of the society's authority could no longer be tolerated.

During the week-end, there were meetings at many of the locomotive depots in the Eastern and North-Eastern Regions. At most of them, it was decided not to accept the recommendations for strike action put forward by the unofficial conference, and to support the union's action on the subject of lodging turns. At the annual conference of the National Union of Railwaymen last Saturday, the assistant general secretary, Mr. F. S. Green, said that the union had signed an agreement about lodging turns, and would stand by that agreement as long as it existed, no matter how unpalatable. If agreements were not honoured, Mr. Green commented, "it was good-bye to trade union negotiations."

Cable Makers and the Monopolies Commission

In his chairman's statement at the annual meeting of British Insulated Callender's Cables, Ltd., on Thursday of last week, Sir Alexander Roger commented on the Government's decision to endorse the policy advocated in the report of the Monopolies Commission on cables. Sir Alexander said that the trade associations concerned—the Cable Makers' Association and the Covered Conductors Association—were asked by the Minister of Supply for an assurance that they would bring their arrangements into conformity with the Commission's conclusions. The associations were informed that if they were disposed to give a voluntary undertaking on the lines indicated, the Government would not propose to exercise its powers to make a Statutory Order under the Monopolies Act of 1948. For the associations to be asked to accept the Monopolies Commission's recommendations "voluntarily" was ironical, Sir Alexander commented, since as the matter stood at present, there was no choice but to accept the Government's decisions or to have an order made.

It was true, Sir Alexander continued, that the associations had been left with the ability to fix minimum prices for certain cables and insulated wires. There were, however, two qualifications, the first of which was that the level of the prices was no higher than would provide a reasonable profit to the lowest cost producer of each kind of cable (there were hundreds of kinds involved); and the second that "costs and profits should be reviewed from time to time by the appropriate Government department to ensure that the minimum prices are fixed in accordance with the principles recommended." It should be borne in mind, Sir Alexander said, that the lowest cost producer in the common sizes of some small cables could be one who spent no money whatever on technical research and development, or sales marketing, particularly overseas, and that could bear very heavily on those who had been the technical and commercial leaders in the industry for many years.

Commerce and industry throughout this country, Sir Alexander urged, should pay great regard to the conditions proposed to be laid upon the Cable Makers' Association and the Covered Conductors Association in fixing their minimum prices. If similar theories were promulgated in future reports of the Monopolies Commission and endorsed by the Government, then there would be only one outcome; the Government would be fixing the profit rates of substantial sections of British industry, and particularly of the vital and progressive electrical industry. That, Sir Alexander observed, would be something quite new in the annals of British industry, the consequences of which were fraught with the gravest possibilities to all sections of the community. The cable-making industry, Sir Alexander said, was faced with one of two evils—the Government supervision of costs and profits or cut-throat competition with no agreed fair trading basis.

Overseas Trade

Provisional figures concerning the trade of the United Kingdom during May show that exports were valued at £228,900,000. If the two months, April and May, are taken together exports averaged £226,900,000 a month, which was 1 per cent above the average in the first quarter of this year and 8 per cent higher than the average for the second quarter of 1953.

Re-exports in May were valued at £9,000,000. Imports in May were valued at £280,400,000, making a monthly average of £277,000,000 for the first five months of this year, or 2 per cent below the monthly average in the first half of 1953. The excess of imports over total exports in May was £42,600,000, which corresponds exactly with the average excess for the first five months of the year, and was 33 per cent below the monthly rate in the first half of 1953.

The Board of Trade says that United Kingdom exports to North America in May were valued at £25,500,000. For the two months, April and May, they averaged £25,300,000 a month, which was 14 per cent less than the monthly average in the second quarter of last year. Exports to the U.S.A. in April and May averaged 11 per cent less than in the second quarter of 1953; exports to Canada in the two months were at a rate of 18 per cent below the monthly average for the second quarter of last year.

River Tees Handbook

This week, there has been published *The River Tees Handbook*, which has been compiled under the authority of the Tees Conservancy Commission and other river interests. It contains a wealth of information about the trade of the Tees-side ports, the available facilities, and the industries in the neighbourhood. Details of the river wharves are included and there are also up-to-date statistics about the trade of the port of Middlesbrough. In addition, the handbook gives a historical survey of the establishment and work of the Tees Conservancy Commission.

A foreword has been contributed by Alderman B. O. Davies, chairman of the Commission. In it, he says that in little more than 100 years the River Tees has emerged from comparative obscurity to become one of the principal rivers in the United Kingdom. Alderman Davies adds that the iron and steel, chemical and engineering industries have in hand developments costing many millions of pounds, and that the shipbuilding and ship-repairing industries look forward confidently to years of full employment. The trade of the port, he says, has never been better, and in the near future it is hoped to make a start on the construction of the Conservancy Commissioners' Lackenby deep-water dock scheme.

Iron and Steel Production

The British steel industry established another production record in May, when the output of ingots and castings averaged 374,500 tons a week. This represented an annual production rate of 19,476,500 tons, compared with a rate of 19,155,000 tons in April, and of 18,236,000 tons in May last year. Pig iron output in May averaged 231,400 tons a week and was thus at an annual rate of 12,033,000 tons. In May last year, the annual production rate was 11,165,000 tons.

Tool Steels

In the current issue of its *Monthly Statistical Bulletin*, the British Iron and Steel Federation has included a survey of tool steels, including high-speed steel. It emphasises that not only do these steels form an extremely valuable sector of British steel production—their value being out of all proportion to the tonnage produced—but that they have also an extremely high conversion value.

The survey says that the markets for general tool steels are vastly wider and more varied than those for high-speed steels. Analysis of the figures for the fourth quarter of 1953 shows that of home deliveries of 6280 tons, 450 tons went to stock-holding merchants; and that, of the remainder, one-third went to specialist toolmakers, a small proportion (7 per cent) to iron and steel producing firms, and two-fifths to tool-using industries making their own tools. This latter group included general engineering, 15 per cent; the machine tool industry, 9 per cent; agricultural machinery, 7 per cent; motors, cycles and aircraft, 6 per cent; electrical machinery and apparatus, 4 per cent. This left a residue of nearly 20 per cent (about 1100 tons) which went to a variety of industries, ranging from marine engineering and railway rolling-stock manufacturers to drop-forgers and spring makers.

The *Bulletin* says also that direct exports of tool steels, like those of high-speed steels, have maintained a reasonably steady rate during the last few years; they amounted to 7680 tons in 1951, 8000 tons in 1952, and 7885 tons in 1953. In both high-speed and tool steels there have been changes in the export markets in recent years. United Kingdom restrictions on high-speed steel exports, which were imposed when tungsten became scarce, were relaxed later than those imposed by Germany and Austria. The *Bulletin* says that competition from those countries has been increasingly severe in many parts of the world—in Switzerland, India and South America, for example—and, as is well-known, it is harder to win back markets than to keep them.

The survey ends by suggesting that export competition in high-speed steel is largely a matter of price and, in tool steels, service in the way of quick deliveries of small lots is as important a factor. In this respect, competition has so far been easier to meet, except in South America. Most of the United Kingdom's traditional markets within and outside the Commonwealth have been held, in spite of the severity of German and Austrian competition.

Notes and Memoranda

Rail and Road

SWANSEA AND MUMBLES RAILWAY ANNIVERSARY.—This month the Swansea and Mumbles Railway celebrates the 150th anniversary of its incorporation in 1804 as the Oystermouth Railway or Tramroad Company. Originally the line connected Swansea and Oystermouth—later being extended to Mumbles Pier—and it has the distinction of having been the first railway in the world to convey fare-paying passengers. It was opened for traffic in April, 1806, and the first fare-paying passengers were carried on March 25, 1807. At the start, motive power was provided by horses and these continued to be used for both freight and passenger traffic until 1885. Steam locomotives were then introduced and continued in use until 1929, when electric tramcars were first put into service. The British Thomson-Houston Company, Ltd., supplied electrical equipment for the eleven double-deck cars, each seating 106 passengers, which were introduced, and, as far as is known, these are the largest tramway cars ever built.

OLD RAMSBOTTOM LOCOMOTIVE.—Recently, Imperial Chemical Industries, Ltd., presented to the British Transport Commission for inclusion in its collection of historical locomotives a Ramsbottom locomotive which was built at Crewe in 1865. This locomotive was one of thirty-six tank engines built for general shunting work on the London and North-Western Railway, and is mechanically almost the same as when it was built eighty-nine years ago. It is still in full working order and was in full service until a few months ago in the Kynoch works, which were previously owned by Kynoch, Ltd., the predecessors of the I.C.I. Metals Division. Before coming to Kynoch works, the locomotive had been rebuilt twice by the L.N.W.R., in 1887 and 1898—when a Webb chimney and a cab were fitted—and it was bought by Kynochs in 1919. Minor modifications made more recently included the fitting of larger buffers and Ross pop safety valves. The engine shows former Crewe practice in its cast iron wheel centres with I-section spokes (introduced by Ramsbottom on this class), brake gear with wooden blocks, and a "drop-down" smokebox door on a horizontal hinge. It retains the original Ramsbottom design of double-beat regulator and cylindrical firebox. The boiler and firebox were renewed by W. G. Bagnall, Ltd., in 1935, but apart from strengthening to permit a working pressure of 160 lb instead of the former 120 lb, the unit is identical with that installed by the L.N.W.R. The cylinders are of the original dimensions, 14in by 20in, the wheels are 4ft 1in diameter, and the weight in working order is 23 tons.

CONINGTON NORTH SIGNALBOX.—To enable the gates at the nearby level crossing to be worked mechanically from the box instead of by hand, Conington North signalbox, just south of Holme Station on the East Coast main line, Eastern Region, British Railways, was recently moved from its former site about 75 yards south of the crossing to a new site immediately next to the crossing. A bed of old sleepers was prepared along the running path between the two sites and a roller path consisting of 12in by 12in timbers was laid down, on top of which were fixed the race rails, being bull-head rails laid on their side. The preparation of the box for rolling involved internal and external strutting and raising the box to the level of the roller path, with 9in by 7in rolled steel joists fixed through the walls from side to side. These were in turn suspended from four 24in by 7½in rolled steel joists running the length of the box, two inside and two outside, supporting each main wall. Other girders, also fixed to the larger joists, supported the end walls and concrete staircase which was carried along with the box. The structure was then lifted off its dampcourse to the level of the runway by four 200-ton jacks applied to the 24in by 7½in joists, one jack at each corner of the box. The box was raised a height of 21in above its dampcourse preparatory to fixing the race rails and steel balls. The lower race rails were continuous throughout the length of the roller path, including the length of the box. Four upper race rails were provided, each about 7ft 6in long, at each corner of the box, supported on 3½in diameter steel balls placed approximately 6in apart and these were continuously, fed into the race rails as the movement took place. The subsequent operations involved the lowering on to the temporary brick piers which took the weight until the lower portions of the walls were restored, after which all strutting and steel supports were removed. During the operation only a minimum of stripping of the signalling equipment was done, being practically confined to the removal of the signal rodding in the lower chamber of the box. The box was out of action for a period of three weeks, but the actual movement was completed in a total period of about four hours. Whilst the work was going on, block working was carried out between Conington South and Holme signalboxes. The work was undertaken by Wellerman Bros., Sheffield.

Miscellanea

NATURAL GAS EXPLORATION.—In the search for natural gas on behalf of the Gas Council, Anglo-Iranian's D'Arcy Exploration Company has cleared a site at Crowborough, Sussex, in preparation for drilling a well which is expected to reach a depth of 2000ft.

INSTITUTION OF PRODUCTION ENGINEERS.—The Institution of Production Engineers has announced the re-election of Sir Walter Puckey as president. He will begin his second year in that office on July 1st. Mr. G. Ronald Pryor has been elected chairman of the council, and Mr. H. G. Gregory, vice-chairman. The headquarters of the Institution of Production Engineers are now at 10, Chesterfield Street, London, W.1.

FILM ON MOBILE CRANE MANUFACTURE.—There was recently shown in London for the first time a new film entitled "The Inside Story," which has been made for George Cohen and Sons, Ltd., to describe the manufacture of the "K.L." mobile cranes at the works of K. and L. Steelfounders and Engineers, Ltd. With a well-chosen commentary this film shows all stages in the manufacture of the cranes from the making of the steel to the final acceptance testing of the completed cranes under rigorous conditions on the firm's test site.

COURSE ON INSTRUMENT MAKING.—The City and Guilds of London Institute has prepared a five-year part-time course in instrument making which is designed to meet the needs of craftsmen in instrument making or light precision engineering. The scheme is intended to supplement by part-time study the normal craft apprentice's industrial training, and to be complementary to it. The course is arranged in two stages, intermediate and final, the intermediate stage being planned to cover a period of three years and the final stage a further period of two years. The scheme will operate from the beginning of the session 1954–55.

FAR EASTERN WATER RESOURCES.—The United Nations' Economic Commission for Asia and the Far East is organising a number of activities to promote the development of water conservation and flood protection schemes in its area. A report entitled "River Training and Bank Protection" has recently been published by the Commission and is the fourth of its publications devoted to the control of river floods. One of the Commission's press releases gives details of a conference in Tokyo on May 17th to 22nd, at which a large number of technical papers were presented on various aspects of the utilisation of Asia's vast water resources, for irrigation, navigation, water power development, flood control, and the conservation and protection of soil from erosion.

INTERNATIONAL MEETING ON PALLETS.—The second International Meeting on Pallets is due to be held under the auspices of the International Organisation for Standardisation in London at British Standards House, from June 21st to 23rd, and will be attended by representatives from several countries, including Australia, Belgium, France, Germany, Netherlands, Norway, Sweden, Switzerland and the United Kingdom. The conference will continue the discussions started in December, 1952, when agreement was reached on two sizes of pallets for international use. Further proposed sizes will be discussed, as will the physical and dimensional characteristics of pallets and the definitions applied to the different kinds of pallets available. Other items which may be discussed, if good progress is made, include the securing and limitation of loads on pallets.

PRODUCTIVITY IN THE FERTILISER INDUSTRY.—It has been stated that last year the British fertiliser industry delivered to farmers during sixty critical days of the spring planting season enough fertilisers to make a hill 1000ft high and half a mile broad at the base, and that smaller deliveries continued throughout the year at a total cost to the farmer of £67,250,000. The methods of handling and manufacture of this mass of material, with its influence on the cost and quantity of food production, are the subject of the fourteenth review to be published by the British Productivity Council of the industries which sent productivity teams to the U.S.A. under the auspices of the Anglo-American Council on Productivity. Representatives of the British superphosphate and compound fertiliser industry visited America in 1949 and the steps taken by firms in the industry to improve their methods have, in the main, followed the lines suggested by the productivity team in its report which was published in 1950. The review says that among the major developments in fertiliser manufacture since the war have been an expansion in the production of granulated fertilisers, the setting up of triple superphosphate plants and the development of ammoniated superphosphate and nitrophosphate. Probably the most significant post-war development, however, has been the introduction of mechanical handling equipment.

PRODUCTION IN NORTHERN IRELAND.—The report on the 1952 Census of Industrial Production in Northern Ireland, which has been published by the Ministry of Commerce, shows that the total gross output of industry in 1952 amounted to £320 million, and that an average of 201,500 persons were employed. These figures are based on a total of 1667 returns relating to concerns which individually employed more than ten persons on the average during the year. Small firms employing ten or fewer persons were exempted from the census. The gross output, which is the total selling value of goods made and the value of production work done in all branches of industry in the Province, contains an element of duplication since the value of semi-finished goods made by one section of industry and supplied to another for use as material in the manufacture in Northern Ireland of more finished products is accounted for more than once. For 1952 this duplication has been estimated to be £57,000,000, giving a gross output free from duplication of £263 million. The report shows the extent of the trade recession in 1952. There was a fall in the value of total industrial output, due to lower output in the textile and clothing industries, and in the timber and furniture, paper and printing, and miscellaneous group of trades. The decline in activity in these trades was, however, partly offset by increases in the engineering, building, food, drink and tobacco trades. The total net output of all industries covered by the census was lower by £7,000,000, and employment by 10,000 persons, the great majority of those thrown out of work being women and girls. The value in 1952 of Northern Ireland's exports of industrial products to places outside the United Kingdom was £33,000,000.

METALLURGICAL FILMS.—The British Iron and Steel Federation recently showed two films which have been added to those which it makes available on free loan. The first deals with the formation of bainite, which was the subject of a paper published in the *Journal* of the Iron and Steel Institute, November, 1952, by T. Ko and S. A. Cottrell. The film illustrates the work carried out by these authors. Following an introductory explanation of the structures forming during heat-treatment, the film goes on to show by means of time lapse photography the actual formation of martensite and bainite under a "hot stage" microscope. It is regarded as the first successful technique developed for filming the formation of bainite. Using 1·1 per cent carbon, 1·5 per cent chromium steel (EN31), the film first shows at ×24 actual speed the formation of martensite upon quick cooling. The commentary discusses the nature of its formation and growth. It is stated to form by nucleation and very rapid growth, taking about one-millionth of a second. It is a supersaturated solution of carbon in highly stressed α iron, and the distortion of the surface during its formation is also shown. The formation of bainite is then illustrated, using the same steel. Specimens are austenitised at 1250 deg. Cent. for one hour and then cooled rapidly to a transformation temperature between the M_s point and the pearlitic range (270 deg. Cent.). It remains austenitic immediately upon quenching, and the surface is flat except for grain boundaries. As the bainite slowly forms so the surface distorts, and the process is shown at ×60 actual speed. The bainite needles appear to grow by continuous growth from nuclei and stop growing at grain boundaries, and they appear to stand out in relief from the austenitic matrix. The second film is concerned with blister steel. In October, 1951, the fires were drawn from the last Sheffield furnace making blister steel by the old cementation process. The last working days of the furnace are recorded in the film, which describes the complete process.

Personal and Business

SUNVIC CONTROLS, Ltd., Harlow, Essex, states that its telephone number is now Harlow 24231.

THE BUILDING SURVEYORS' INSTITUTE has moved to Temple Bar House, 227, Strand, London, W.C.2.

GROUP CAPTAIN L. R. STOKES has been appointed managing director of Bowmaker (Plant), Ltd., Willenhall, Staffs.

MR. J. C. MILNE, M.I.E.E., has been appointed technical director of The Electric Construction Company, Ltd., Wolverhampton.

MR. L. H. G. STERNE has been appointed head of the Naval Air Department of the Royal Aircraft Establishment, Farnborough.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that Mr. J. S. Makin has been appointed branch manager at the Manchester office.

F. J. BAYNES AND CO., Ltd., is moving on June 24th to Northampton House, St. Paul's Road, London, N.1 (telephone, Canonbury 5811).

BOUND BROOK BEARINGS, Ltd., Lichfield, states that Mr. J. F. C. Goodman has resigned from the board and from the position of sales director.

MR. F. R. LIVOCK, M.I.E.E., has been appointed sales director of Metal Industries (Electrical Division), Ltd., Victoria Station House, London, S.W.1.

STUART DAVIS, Ltd., states that Mr. Arthur Whiston has been appointed sales manager and is now at the company's headquarters at Much Park Street, Coventry.

SEMTEX, Ltd., announces the appointment of Mr. L. H. Griffiths as assistant general manager. Mr. W. Saul succeeds Mr. Griffiths as technical manager of the firm.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., states that Mr. A. E. Grimsdale has been appointed a director of Metropolitan-Vickers Electrical Export Company, Ltd.

THORN ELECTRICAL INDUSTRIES, Ltd., states that the Midlands sales office of the Atlas lighting division has moved to 23, Sheepcote Street, Birmingham, 15 (telephone, Midland 5291).

SIR HAROLD ROXBEE COX, M.I.Mech.E., is resigning his position as chief scientist of the Ministry of Fuel and Power on June 30th, in order to take up appointments in the engineering industry.

THE PRESIDENT OF THE BOARD OF TRADE has approved the appointment of Mr. J. L. Girling as Comptroller-General of Patents, Trade Marks and Designs in place of the late Sir John Blake.

THE BRITISH TRANSPORT COMMISSION announces that Mr. John Ryan and General Sir Daril Watson have been appointed additional members of the board of management of the Commission's inland waterways.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION states that Mr. J. D. W. Jeffery, A.M.I.C.E., has been appointed assistant chief engineer at headquarters, following the appointment of Mr. G. H. Hargreaves as deputy chief engineer (civil engineering).

THE LORD PRESIDENT OF THE COUNCIL has appointed Sir Hugh Beaver, M.I.C.E., to be chairman of the Advisory Council for Scientific and Industrial Research, in succession to Professor Sir Ian Heilbron, F.R.S., whose term of office expires on September 30th.

MR. V. J. CHALWIN has resigned from the positions of chairman and managing director of Brush Electrical (Australia) Pty., Ltd., and British Oil Engines (Australasia) Pty, Ltd. Mr. A. P. Quarrell has been appointed chairman of British Oil Engines (Australasia) Pty, Ltd., and managing director of Brush Electrical (Australia) Pty., Ltd. Mr. J. E. Cestell becomes managing director of British Oil Engines (Australasia) Pty., Ltd.

British Patent Specifications

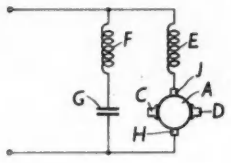
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

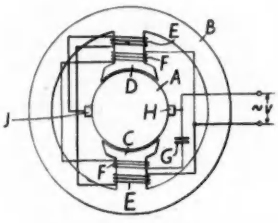
Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ELECTRICAL ENGINEERING

709,354. August 8, 1952.—SINGLE-PHASE COMPOUND MOTORS, Otto Spahr, 43, Optingenstrasse, Berne, Switzerland.

Referring to the drawings, the motor comprises an armature *A* and a stator *B* having two poles *C* and *D*. The armature as well as the stator are laminated. A series winding *E* and a shunt winding *F* are arranged on the poles. A condenser *G* is connected in series with the shunt winding *F*. This condenser is preferably so dimensioned that, together with the inductance of the shunt winding, it forms an oscillating circuit tuned to the frequency of the mains. The operation in the resonance range tends to keep the shunt field current at a steady value under different operating conditions. At no-load the shunt current is large with respect to the series current, because the oscillating circuit (*F* and *G*) is practically in resonance. It produces the main share of the flux. The no-load



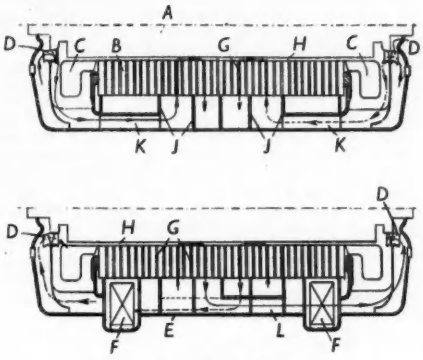


No. 709,354

series current, in comparison thereto, is very small. At full load the series current surpasses the shunt current, which is nearly constant and, according to the design of the machine, has little phase shift. The shaft-shift between the voltage and the resulting exciting flux is very small and the efficiency at full load is high. The series and shunt windings are arranged on the same magnetic poles and in consequence of this arrangement are very closely coupled to each other. If at full load a very strong series current flows, a voltage is induced in the shunt winding which almost balances the external voltage applied to the shunt field winding. This is a contributing reason for the fact that the effect of the shunt field is reduced only at full load. Similarly, at no-load a counter voltage is induced in the series winding which causes an additional decrease of the effect of the series field excitation. Thus a machine is obtained which at no-load has an almost pure shunt characteristic and at full load or stopping a series characteristic, so that the motor has a very large starting moment. The commutation is very favourable at all operating conditions and the sparking of the brushes *H* and *J* is almost negligible.—*May* 19, 1954.

705,988. June 9, 1952.—GAS-FILLED ELECTRICAL GENERATOR, Aktiengesellschaft Brown Boveri and Cie., of Baden, Switzerland.

The object of the invention is to enable cooling to be maintained when one of the coolers is put out of operation. In the accompanying drawing the lower half of a hydrogen-cooled turbo-generator is shown in vertical and horizontal longitudinal section. *A* is the rotor and *B* the stator of laminated iron. Coil ends are shown at *C* and *D*, fans fixed to the ends of the rotor serving to circulate the cooling gas. At each end of the machine casing *E* are two diametrically opposed coolers *F*, which are housed vertically in recesses in the machine casing. These coolers cool the gas which circulates in the machine in a closed circuit. Radial cooling slots *G*, as well as the air gap *H* between the rotor and the stator, cool the stator iron. In order to compel the cooling gas to follow the desired path inside the gastight casing, separating walls *J* and axial channels *K* and *L* respectively are provided in the space between the stator laminations *B* and the machine casing *E*. Starting from the left end of the machine, the fan produces a movement of the cooling gas through the axial channel *K*. This axial stream of gas, which is indicated in the drawing by full lines, is caused by the separating walls *J* to flow radially inward through the cooling slots *G* in the stator iron, along the air gap *H* between the stator and the rotor, and then, due to a further separating wall in the middle of the machine, radially outwards through further stator cooling slots until it finally reaches the axial channel *L*. From this channel the gas then flows in the axial direction to the cooler *F* at the opposite end of the machine. The fan at the right end of the machine forces the gas which has been cooled in the cooler *F* to flow in an analogous manner through the machine to the left end. This gas stream which is indicated



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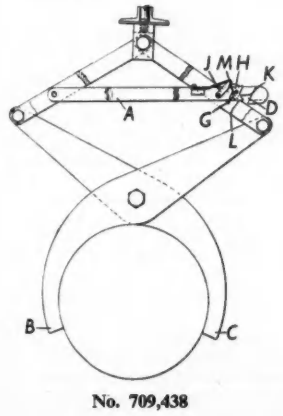
by broken lines, first passes in the axial direction through the channel *K* at the right-hand end, radially inwards through cooling slots in the stator iron, along the air gap between the stator and the rotor, radially outwards through the stator cooling slots, through cooler *F* to the fan *D* at the left-hand end of the machine. The cooling medium streams are diverted at the centre of the machine so that they cross each other. For each axial half of the generator there are thus two cooling medium streams which intersect each other and when one of the coolers is out of operation the gas is still adequately cooled by the cooler located at the other end of the machine. The number of intersecting gas streams can be increased by providing additional axial channels of the kind described.—*March* 24, 1954.

CRANES AND LIFTING APPLIANCES

709,438. June 8, 1951.—AUTOMATIC LIFTING DOGS, British Electrical Repairs, Ltd., Empire House, 10, Charlotte Street, Manchester, 1. (*Inventor: Alexander Davidson.*)

The invention relates to automatic lifting dogs in which a pair of toggle links is pivoted at one end to one another at the point where the normal lifting hook or the like is attached and also pivoted at their other ends to the ends of a pair of scissors-like interconnected gripping arms having jaws by which an article is held whilst being lifted and transported. The object of the invention is to provide a simplified but efficient mechanism for controlling the entry of the stop pin into the pin engaging



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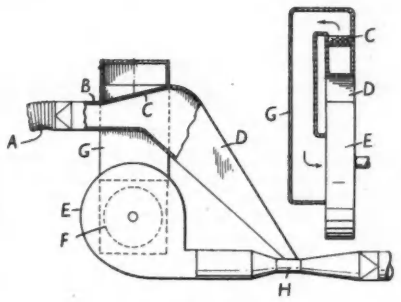
portion of the recess in the latch which prevents closing of the jaws preparatory to a subsequent lifting operation. The latch lever *A*, which is pivoted at one end to one of the toggle links connecting the lifting hook to the gripping arms, having gripping jaws *B* and *C*, has a double-ended recess *D* on its underside towards its free end, which receives a pin *G* upon the toggle link each time the lifting appliance is lowered. Upon the latch lever is mounted a ratchet wheel *H* which is given a rotary movement by the pin each time the lifting dog is raised. The ratchet wheel makes a quarter turn each time it is turned and a pawl *J*, spring loaded, holds the wheel against rotation. At each lowering of the lifting dog the pin *G* enters the end *K* of the recess nearer to the free end of the latch lever. This is the end of the recess which limits the extent to which the gripping jaws *B* and *C* can separate from one another. As shown, the pin is clear of the recess and the jaws are able to approach one another freely during a lifting operation. When the dogs are lowered the ratchet wheel presents a cam surface *L* at the underside of the latch lever, which prevents the pin entering the end *M* of the recess further from the end of the latch lever *A* and allows it to enter the end *K*. When now the lifting dog is raised the pin tends to move from the outer to the inner end of the recess and in so doing it turns the ratchet, when the pin is allowed to move into the inner end *M* of the recess, which has the effect of preventing the jaws closing on a workpiece.—*May* 26, 1954.

CONVEYORS

709,606. June 26, 1952.—PNEUMATIC CONVEYORS, Douglas Frederick Lott, 65, Berkeley Road, Kingsbury, London, N.W.9.

The object of the invention is to provide an improved and simplified apparatus in which the material is extracted from the air stream, by-passes the fan, and is later reintroduced into the air stream by means of a venturi-like device, the whole apparatus being closed to the atmosphere. As shown in the drawing, *A* is a flexible circular inlet trunking which joins to a rigid rectangular section trunking *B*, the upper wall of which flares upward in the form of a screen *C*, the inlet trunking continuing as a downward inclined tapering portion *D*. *E* is the casing of a fan and between the screen *C* of the inlet trunking



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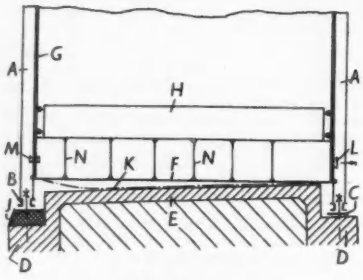
and the central air inlet aperture *F* of the casing is arranged a vertical trunking *G*. The outlet of the fan casing leads through a short trunking to a venturi-like device *H*, to which the lower end of the portion *D* of the inlet trunking joins. The venturi-like device continues as a delivery trunking as shown. In operation, the fan causes suction in the inlet trunking *A* and a stream of air loaded with grain or other material to be conveyed passes along it. When the air stream passes below the upper end of the vertical trunking *G* the air is sucked upwards whilst the conveyed material of the air stream flies on by its own weight down into the inclined portion *D*. The air is passed through the fan and is forced through the venturi-like device *H*, where the previously extracted conveyed material is reintroduced into the air stream. There is a certain amount of pressure loss in the inlet trunking due to drag and the venturi-like device can readily be adjusted so that its suction just counterbalances this pressure loss.—*May* 26, 1954.

GAS HOLDERS

709,405. September 15, 1950.—TRUING THE METAL BOTTOM OF A GAS HOLDER, Maschinenfabrik Augsburg-Nürnberg A.G., of Nürnberg, Germany.

Gas holders which are erected on insecure ground, more particularly in mining districts, will eventually require truing up so that they may be brought back into the vertical position. The invention consists in a method which enables the truing up to be carried out in a much simpler and surer manner than hitherto. As the drawing shows, the corner posts *A* of a gas holder rest in a known manner on supports *B* and *C* on the foundation *D*. On the foundation plate *E* rests the holder bottom *F*, which is connected in a gastight manner with the holder shell *G*. In the gas holder there is arranged in the usual way the plate *H*, which bears in a gastight manner against the holder shell. It is assumed that the foundation has sunk at its left-hand side and occupies the inclined position indicated in the drawing. The holder shell *G* has been raised at its corner posts by such an amount that it again occupies the vertical position shown. After the raising operation an intermediate layer *J* of concrete has been placed under the

supports *B* and *C*. The unreinforced bottom *F* sags, however, and occupies a position somewhat like that indicated by the dot and dash line *K*. For raising it and bringing it into its horizontal position the plate *H* is attached to the holder shell *G*. In the shell there is provided an aperture *L*, to which a pump can be connected, and an inlet valve *M*, which allows air or gas to flow in, when a definite difference in pressure is established between the atmosphere and the interior of the holder. Furthermore, stanchions *N* are



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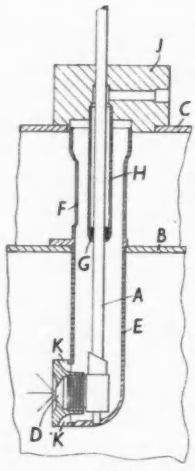
suspended from the plate *H*, and are of equal length corresponding to the distance between the plate and the holder bottom. On suction being applied at *L* the bottom will lift out of the position *K* in consequence of the internal vacuum, until it bears against the stanchions *N*. The valve *M* will prevent an excessive reduction in the internal pressure of the holder, which might result in damage. When the bottom *F* has taken up its horizontal position sand is blown into the space between it and the foundation plate *E* so that after the removal of the vacuum it will retain its flat position.—*May* 26, 1954.

BURNERS AND SPRAYERS

709,592. March 6, 1952.—LIQUID FUEL BURNERS, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventor: Alan Joseph Gerrard.*)

The invention relates to liquid fuel burners for use in the combustion chambers of jet engines and gas turbines. Referring to the drawing, a straight fuel pipe *A* is mounted within and at right angles to the axis of the combustion chamber *B*, having one end extending across an air jacket *C* surrounding the combustion chamber. At its inner end this pipe has secured to it an atomising nozzle *D* having its axis at right angles to the pipe. The fuel pipe is surrounded and enclosed by an air tube *E*, which also extends across the air jacket, and in the part of the tube which lies within the jacket is formed an aperture *F*, through which air can enter from the jacket. At a suitable position in the air tube there is provided a second nozzle *G*, through which a jet or jets of fuel can be discharged into the air tube. This nozzle receives the fuel to be vaporised from a pipe *H* surrounding the pipe *A*. The two pipes are fed from different sources through a fitting *J* to which the air tube is attached and which is supported on the outer wall of the air jacket. Alternatively the second nozzle *G* may be mounted on and supplied by the same pipe as the atomising nozzle *D*. The liquid discharged from the second nozzle is vaporised by heat transmitted through the air tube from the combustion chamber, and the mixture of vapour and air is discharged to the combustion chamber through orifices *K* in the inner end of the air tube adjacent to the atomising nozzle.—*May* 26, 1954.



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TWO NEW POWER STATIONS.—The British Electricity Authority has received the consent of the Minister of Fuel and Power to the establishment of two new power stations, one at Erith, Kent, and the other at Elland, Yorkshire, to be known as Belvedere power station and Elland power station respectively. The Belvedere station will have an installed capacity of 480MW (640,000 h.p.), made up of eight 60MW turbo-generators, and the Elland station an installed capacity of 180MW (240,000 h.p.) provided by three 60MW turbo-generators. In both stations each turbo-generator will be served by a boiler unit having an evaporative capacity of 550,000 lb of steam an hour. The Elland station consent also covers two cooling towers, each having a capacity of 3,000,000 gallons of water an hour.

Technical Reports

Indirect Lightning Surges on Overhead Distribution Lines (Ref. S/T 75). By R. H. Golde, Ph.D., M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 30s., postage 6d.—It has been known for some time that lightning faults on high-voltage transmission lines of, say, 66kV and above are caused exclusively by direct strokes to a phase conductor or to an overhead earth wire or tower with subsequent back-flashover. It is also generally considered that distribution lines of 33kV or below may sustain lightning faults as a result either of a direct stroke or of an indirect lightning surge produced by a stroke which does not strike the line or which strikes an earthed part of the line without causing a back-flashover. However, the problem of the relative importance of direct and indirect lightning surges has not so far been solved. There is basically, no reason to assume that direct and indirect lightning surges affect an overhead line in the same manner. Again, it cannot be expected that a given protective device is equally effective against both kinds of surge. It is for these reasons that a knowledge of the frequency of occurrence of direct and indirect surges is important to the distribution engineer.

The present report is intended to contribute to the solution of the above problem by examining the amplitudes and wave shapes of indirect surges and the frequency of occurrence of direct and indirect surges on lines of different types of construction.

Self-Adjusting Welding Arcs (Ref. Z/T 91). By J. C. Needham, B.Sc. (Eng.). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—This report deals with a preliminary examination of the mechanism of arc length control of the "self-adjusting" arc and particularly with the effects of the output characteristics of the welding power source on the degree of self-adjustment of arc length. The sources compared are a commercial d.c. welding generator, a low-voltage d.c. battery with series resistance, and a low-voltage a.c. transformer with series reactance. The effects of changing the wire feed rate, the current setting and the open-circuit voltage are considered in relation to the degree of self-adjustment.

The self-adjustment of the arc length due to the power circuit characteristics increases rapidly and is very pronounced as the open-circuit voltage approaches the arc voltage. At low open-circuit voltages on direct current the arc current is scarcely predetermined, but immediately rises until it burns off the electrode at the required rate. The arc is stable and the arc length is substantially independent of the wire feed rate over a comparatively wide range, but is controlled by the open-circuit voltage and series impedance.

With an auxiliary source for cyclic arc reignition the arc can be run on alternating current at low r.m.s. open-circuit voltages. Although the degree of self-adjustment is less on alternating current than on direct current, it is still satisfactory.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

HEXAGON SOCKET SCREWS AND WRENCH KEYS

No. 2470 : 1954. Price 4s.—This standard covers all kinds of socket screws in common use and also standardises the wrench keys for use with them. It provides for screws with UNC and UNF threads as well as for the B.A., B.S.W., B.S.F. and B.S.P. (parallel) threads, and the general dimensions for the various screws are also in accord with current American practice.

The requirements in this standard for socket set screws supersede those given for socketed grub screws in B.S. 768, "Grub Screws," and an amendment to be issued shortly will authorise their deletion from that standard.

ROUND TINS FOR LUBRICATING GREASES

No. 2469 : 1954. Price 2s. The newly-published British Standard for round tins for lubricating greases standardises the nominal diameters and gross lidded volumes based on nominal net weights with the requisite ullage. Heights of tins are not defined as their standardisation would result in differences in the volumes of the tins owing to the fundamental differences in the designs of lever rings and caps. Two of the diameters warrant special mention. A 7 lb tin measuring 6¼in in diameter has been popular in the lubricating grease industry for many years. It is, however, scarcely used in any other industry and the grease industry feels that it will be in its interests gradually to change over to the more usual 7in diameter so that it can reap the benefits that inevitably accrue from adopting an article that is in large-scale production, even though the change-over may take some time. The new diameter has, therefore, been included in the standard. For 1 lb tins only the 3½in diameter is included, which is made by a large number of tin box manufacturers. A 3½in tin is also known to be in use which compares with a tin used by the grease industry in the United States and it is possible that this alternative diameter may be included in a subsequent revision of the standard.

Contracts

LEYLAND MOTORS, Ltd., has received orders, from India, for 190 Comet "90" passenger vehicle chassis. These orders have been placed by Delhi Transport Services, Bombay State Transport, and the Ahmedabad municipality. The orders are valued at nearly £300,000.

THE NEW ZEALAND GOVERNMENT RAILWAYS have placed an order with W. G. Bagnall, Ltd., Stafford, for the supply of ten 240 h.p., 0-6-0 diesel mechanical shunting locomotives. The locomotives will be fitted with "M4AA6" oil engines manufactured by the National Gas and Oil Engine Company, Ltd.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., has received a contract from the City and County Borough of Belfast for the supply and installation of approximately 7 miles of 0·30 square inch, three-core 110kV, oil-filled cable, together with auxiliary cables and accessories. The installation will link the Belfast Municipal Electrical Power Station West with the system of the Electricity Board for Northern Ireland at Donegall substation.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., has announced the receipt from the Iraq Development Board of an order, worth £69,000, for the supply of six Callender-Hamilton bridges. Designed to carry full Ministry of Transport loading, the bridges will provide a double carriageway 24ft wide, together with footways for pedestrian traffic cantilevered outside the main girders. The order entails the supply of 700 tons of steelwork of the Callender-Hamilton type, except that high-tensile steel will be used in place of the normal mild steel.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., and INTERNATIONAL AERADIO, Ltd., have secured a contract for radio communication and direction-finding equipment from the Ministry of Defence of the Republic of Syria. This contract entails the planning and engineering of a complete radio communications network, which is to include automatic and manual v.h.f. direction-finding stations (both mobile and static), with associated v.h.f. ground/air communications facilities. A training school for personnel of the Syrian Air Force is also to be provided by the two companies.

Launches and Trial Trips

WHAKATANE, cargo liner; built by Alexander Stephen and Sons, Ltd., for the New Zealand Shipping Company, Ltd.; length overall 472ft, breadth moulded 62ft 9in, draught 30ft 6in, gross tonnage 8750, service speed 16 knots; six passengers; insulated cargo space 95,000 cubic feet, general cargo space 400,000 cubic feet; three 300kW diesel-driven dynamos, one auxiliary boiler; Doxford oil engine, six cylinders 725mm diameter by 2250mm combined stroke, 7100 b.h.p. at 114 r.p.m. Trial, May.

BORDER FUSILIER, oil tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the Lowland Tanker Company, Ltd.; length overall 547ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,100 tons; twenty-seven cargo oil tanks, two cargo pump rooms, four cargo oil pumps, two 150kW diesel-driven generators, one 75kW steam-driven generator, two auxiliary boilers; Hawthorn-Doxford oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m. Trial, June 9th and 10th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH ROAD FEDERATION

Mon., June 21st.—Royal Empire Society, 18, Northumberland Avenue, London, W.C.2, "The Development of a Modern Highway System," D. C. Greer, 6 p.m.

INSTITUTE OF METALS

Wed., June 30th.—GENERAL MEETING: 4, Grosvenor Gardens, London, S.W.1, "The Brittle Fracture of Metals: Some New Developments," E. Orowan, 5 p.m.

INSTITUTE OF NAVIGATION

To-day, June 18th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Methods of Training in Navigation," Discussion introduced by W. L. S. Harrison, 5 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, June 18th.—EDUCATION DISCUSSION CIRCLE: Engineering Laboratory, The Polytechnic, Battersea, Exhibition of Apparatus, 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, June 18th.—Stephenson Building, King's College, University of Durham, Sir Charles Parsons Centenary Exhibition, 7 p.m. to 8.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Mon., June 21st.—EXTRAORDINARY GENERAL MEETING: Townsend House, Greycoat Place, London, S.W.1, 6 p.m.